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STATISTICAL OXIDANT/PRECURSOR RELATIONSHIPS FOR THE LOS ANGELES REGION

Interim Report

Part II. Data Acquisition and Creation of a Data Base

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by

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ABSTRACT

This interim document reports on Phase II studies for a project involving "Statistical Oxidant/Precursor Relationships in the Los Angeles Basin." The purpose of Phase II is to collect, sort, and process all aerometric and meteorological data needed for the development of a model relating afternoon oxidant levels to morning precursor (HC and NO_x) concentrations in the South Coast Air Basin (SCAB). In addition to collection and compilation of these data, this task involves a preliminary statistical analysis of these data as preparation for Phase III, creation of the empirical model. The principal goal of this preliminary analysis is to select the source and receptor sites and oxidant averaging periods most likely to be conducive to successful model development and to restrict the data base to days having appropriate wind flow to transport air from the chosen source sites to the receptors.

An important conclusion of this study is that an oxidant-precursor model for short-to-medium range transport (e.g., DOLA to Pasadena) will be easier to construct and probably more accurate than one for long-range transport. The major problem is that oxidant-precursor correlations tend to decrease with increasing source-to-receptor separation, becoming significantly negative at the largest transport distances. While this phenomenon seems reasonable physically and is therefore not necessarily indicative of low data quality or interference from unaccounted-for factors, it nonetheless may hinder the successful creation of an oxidant-precursor model involving long-range transport.

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1.0 INTRODUCTION

The South Coast Air Basin* (SCAB) experiences a severe problem with respect to photochemical oxidant pollution. During the summer and early fall, the National Ambient Air Quality Standard (.08 ppm, 1 hour average) is exceeded almost every day, typically by a factor of two to four. On days of extreme photochemical smog in the SCAB, oxidant values up to five or six times the national standard are reached.

The formulation and evaluation of oxidant control strategies for the SCAB have been hindered by the lack of a reliable methodology for relating ambient oxidant levels to precursor (hydrocarbon and nitrogen oxide) emission levels. There is a pressing need for oxidant air quality models that are complex enough to include the realities of the problem but simple enough to be useful in practice. Under contract to the California Air Resources Board, Technology Service Corporation is developing empirical models of the relationship of oxidant to its precursors by performing a statistical analysis of the existing SCAB aerometric data base.

The empirical modeling project is divided into four phases:

I. Data quality review and evaluation
II. Data acquisition and creation of a data base
III. Model development and verification
IV. Application of the model to determining the impact of auto use reductions on oxidant levels.

*Federal designation: Metropolitan Los Angeles Air Quality Control Region.

This interim report presents the results of Phase II. The work of this phase comprises the compilation of the data base for the development of the oxidant-precursor algorithms, plus a preliminary statistical analysis of these data. The ARB and EPA Project Officers will determine whether or not the preliminary correlation coefficients between oxidant and hydrocarbons warrant a continuation with Phase III, the development of the oxidant-precursor models.

1.1 ORGANIZATION OF PHASE II

The primary purpose of Phase II is to collect, sort, and process all aerometric and meteorological data needed for the development of an empirical model relating afternoon oxidant levels to morning precursor (HC and NO_x) concentrations. In addition to collection of these data from various magnetic tapes, punched cards, and handwritten tabulations from the California Air Resources Board, the Southern California Air Quality Management District, and the National Weather Service, this task involves a preliminary statistical analysis of these data as preparation for Phase III. The principal goal of this preliminary analysis is to select the oxidant averaging times, daily wind patterns, and relative weightings of source and receptor monitoring sites which maximize the correlation coefficient of afternoon oxidant levels versus morning precursor concentrations. Since the five "scenarios" developed in Phase I (see Phase I report, Chapter 3.2) were each analyzed separately in Phase II, this report is organized by scenario, with a chapter devoted to each.

Chapters 2 through 6 discuss the five scenarios in the order given above, i.e., from shortest to longest range transport. Each chapter outlines the data handling and analysis procedures followed and results obtained for the corresponding scenario. Chapter 7 lists the major findings, conclusions, and recommendations arising from this study, while Section 1.2 below summarizes these.

1.2 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

The following are the major findings, conclusions, and recommendations for Phase II.

1) The oxidant-precursor correlation coefficients are highly dependent on the geographical separation of the source and receptor sites, ranging from approximately +.6 at low-to-moderate transport distances to -.5 at long distances. Significant positive correlations can be obtained only in the first three scenarios, with their limited transport ranges.
2) Sorting of the data base, particularly by wind speed and direction, can help strenghthen positive oxidant-precursor correlations. The modeling effort should be based on data which have already been sorted to maximize these oxidant-precursor correlations.
3) When negative or insignificant correlations are obtained, (e.g., with the longer transport distances), sorting of the data base by meteorology should be done on physical grounds rather than by its impact on the correlation coefficients. This is because one does not necessarily anticipate strong positive oxidant-precursor correlations in this situation.
4) Any modeling effort should treat the short-range transport scenarios with high positive oxidant-hydrocarbon correlations first, attempting longer-range cases only if the short-range models are successful.

2.0 "SCENARIO I": MID-DAY OXIDANT NEAR A SOURCE AREA

This chapter summarizes TSC's preliminary study of "Scenario I", in which mid-day oxidant levels at Downtown Los Angeles (DOLA) are to be related to morning hydrocarbon and NO_x concentrations at the same site. This is the simplest of the scenarios, in that a single monitoring site is used as both the precursor location and receptor location.

2.1 COMPILATION OF DATA BASE FOR SCENARIO I

The following parameters were chosen for inclusion in the data base for this scenario*:

1) the average of 6-7, 7-8, and 8-9 AM hourly hydrocarbon concentrations at DOLA

2) the average of the 6-7, 7-8, and 8-9 AM hourly NO_x concentrations at DOLA

3) the 10-11 and 11-12 AM and 12-1 and 1-2 PM oxidant concentrations at DOLA

4) the speed and direction of the wind at DOLA at 7, 8, 9, 10, and 11 AM, noon, and 1 PM

5) the average of the 9, 10, and 11 AM and noon surface air temperatures at DOLA

6) the average of the 9, 10, and 11 AM and noon solar radiation at DOLA

7) the daily peak surface air temperature at Mt. Wilson (elevation 5000 ft)

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*Note that all times are Daylight Time (PDT), since the data cover the months May through October.

8) the morning inversion base height at LAX

9) the daily maximum mixing height--both of the estimates provided by the AQMD '99' (weather summary) variable.

As in all scenarios of this project, the data base was restricted to the months of May through October, 1971 through 1975.

The aerometric data were taken from California Air Resources Board data tapes of gaseous pollutant concentrations in the South Coast Air Basin, while most of the meteorological data were from the Southern California Air Quality Management district tapes or written records. The Mt. Wilson daily maximum temperatures were copied from National Weather Service written records.

All of the above variables were collected into a single tape to facilitate the statistical studies which followed. These statistical studies centered on the maximization of the correlation between oxidant concentrations and morning precursor levels at the DOLA station. To maximize the correlation coefficients, we selected various oxidant averaging times and various wind speed-stratified subsets of the data. The wind speeds and oxidant averaging times yielding the highest oxidant-hydrocarbon correlation coefficients were noted for use in Phase III, the development of an empirical oxidant/precursor model.

2.2 PRELIMINARY ANALYSIS OF OXIDANT-PRECURSOR RELATIONSHIP

The first step in the analysis was to determine the correlation between average oxidants for various time periods and the morning hydrocarbon levels. Since Scenario I is concerned with oxidant arising from local emissions, it was felt that the analysis should be restricted to the forenoon and mid-day periods, before more distant source areas can exert a significant influence. Four oxidant values, corresponding to the 10-11 AM, 11-12, 12-1 PM, and 1-2 PM hourly averages, were included in the original data base. Three two-hour averages, 10-12, 11-1, and 12-2, two three-hour averages, 10-1 and 11-2, and one four-hour average, 10-2, were computed and added to the data base. Because some random fluctuations can be expected in any given oxidant reading, it was felt that the longer averaging times, which represent arithmetic averages of multiple oxidant readings, would be more stable than the hourly average readings.

The top row of Table 2.1 and the dashed line of Figure 2.1 present the oxidant/hydrocarbon correlation coefficient for each of the ten oxidant averaging periods studied (i.e., four one-hour averages, three two-hour averages, two three-hour averages, and one four-hour average). As the figure illustrates, the correlation coefficient is highest in the early parts of the period, peaking for the 10-1 three-hour average and reaching a minimum at the 1-2 one-hour value.

The next step was to determine the effect of wind speed on the oxidant/hydrocarbon correlation coefficient, in order to decide which wind speeds to use in the study. For this investigation, a daily total wind vector for the period 7 AM to 2 PM was computed. This vector is the vector sum of the seven hourly wind vectors, 7-8 AM through 1-2 PM. Figure 2.1 and Table 2.1 include the oxidant/hydrocarbon correlation coefficients for the six different wind speed categories studied. These vector average wind speed categories are: less than 2 mph, 2-3 mph, 3-4 mph, 4-5 mph, 5-6 mph, and greater than 6 mph.

Table 2.1 Oxidant—Hydrocarbon Correlation Coefficients

	Oxidant Averaging Periods									
WIND SPEED	OX 10-11	OX 10-12	OX 11-12	OX 10-1	OX 11-1	OX 10-2	OX 11-2	OX 12-1	OX 12-2	OX 1-2
All wind speeds	.420	.430	.418	.431	.412	.419	.411	.376	.375	.350
< 2 mph	.376	.341	.329	.351	.314	.299	.314	.295	.263	.205
2-3 mph	.311	.327	.322	.324	.258	.230	.251	.175	.140	.092
3-4 mph	.522	.515	.496	.517	.468	.475	.473	.424	.415	.386
4-5 mph	.500	.493	.473	.495	.456	.478	.455	.405	.428	.420
5-6 mph	.368	.362	.317	.356	.323	.340	.314	.279	.284	.268
>6 mph	.295	.316	.314	.318	.407	.407	.395	.430	.430	.389
"slosh"*	.288	.285	.274	.286	.296	.299	.296	.294	.285	.252
"slosh" <2 mph*	.426	.380	.348	.381	.321	.305	.318	.289	.255	.198

*"Slosh" pattern is a morning wind reversal dominated by easterly winds before 10 AM and westerly winds after 11 AM. This pattern is discussed in Section 2.4 of the text.

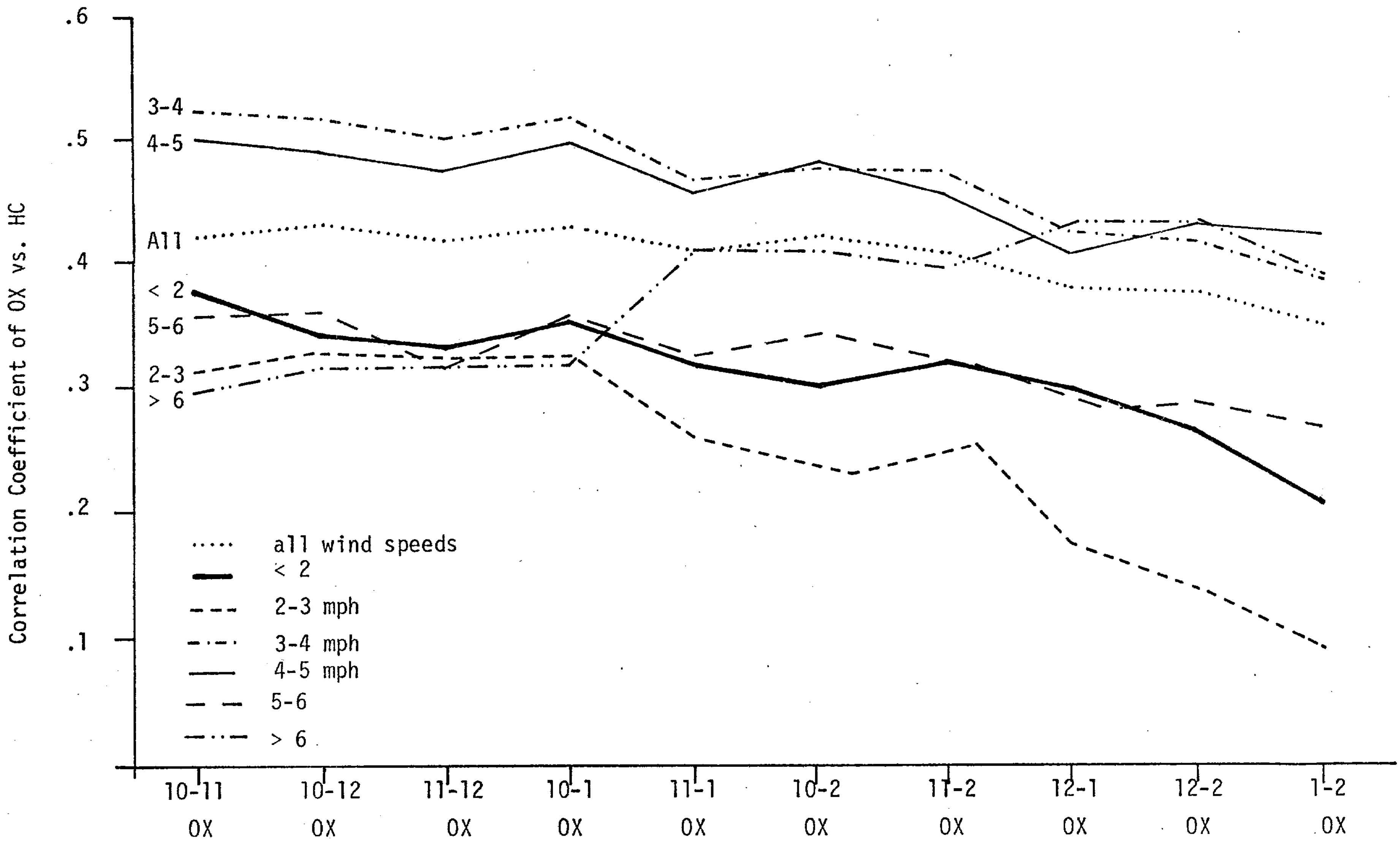

Figure 2.1 Correlation Coefficient of OX vs. HC as a Function of Wind Speed and OX Averaging Period.

Except for the highest wind speeds, correlation coefficients tend to be highest early in the day, peaking at eigher 10-11 AM, 10-12 AM, or 10-1 PM, depending on the wind speed. Because its correlation coefficient is consistently among the highest and because it is a 3-hour average (and therefore presumably more stable), the 10-1 average oxidant level was selected as the dependent variable for the rest of this scenario.

Figure 2.2 illustrates the relationship between the 10-1 oxidant-hydrocarbon and oxidant-NO_x correlations and wind speed and clearly demonstrates the advantage of restricting the study to wind speeds of 3-5 mph, for which the oxidant/hydrocarbon correlation approaches .5. The histogram in Figure 2.3 shows that nearly half of the days in the data base have average wind speeds of 3-5 mph, a fortunate coincidence for this study. Because wind speeds with the highest correlation coefficients are also the most frequently encountered wind speeds, one can restrict the study to days having good oxidant/precursor correlations without tossing out too large a fraction of the data base.

The fairly high (.4 to .5) hydrocarbon-oxidant correlations indicate that the hydrocarbon data are probably reasonably consistent, as any significant random errors among the hydrocarbon levels would produce weaker correlations. In the later, multiple-source scenarios, stations giving abnormally low oxidant/hydrocarbon correlations will be deleted from the data base, on the grounds that such low correlations cast doubt on either the quality of the hydrocarbon data or the extent to which those stations act as source areas for oxidant/concentrations at the receptor site(s).

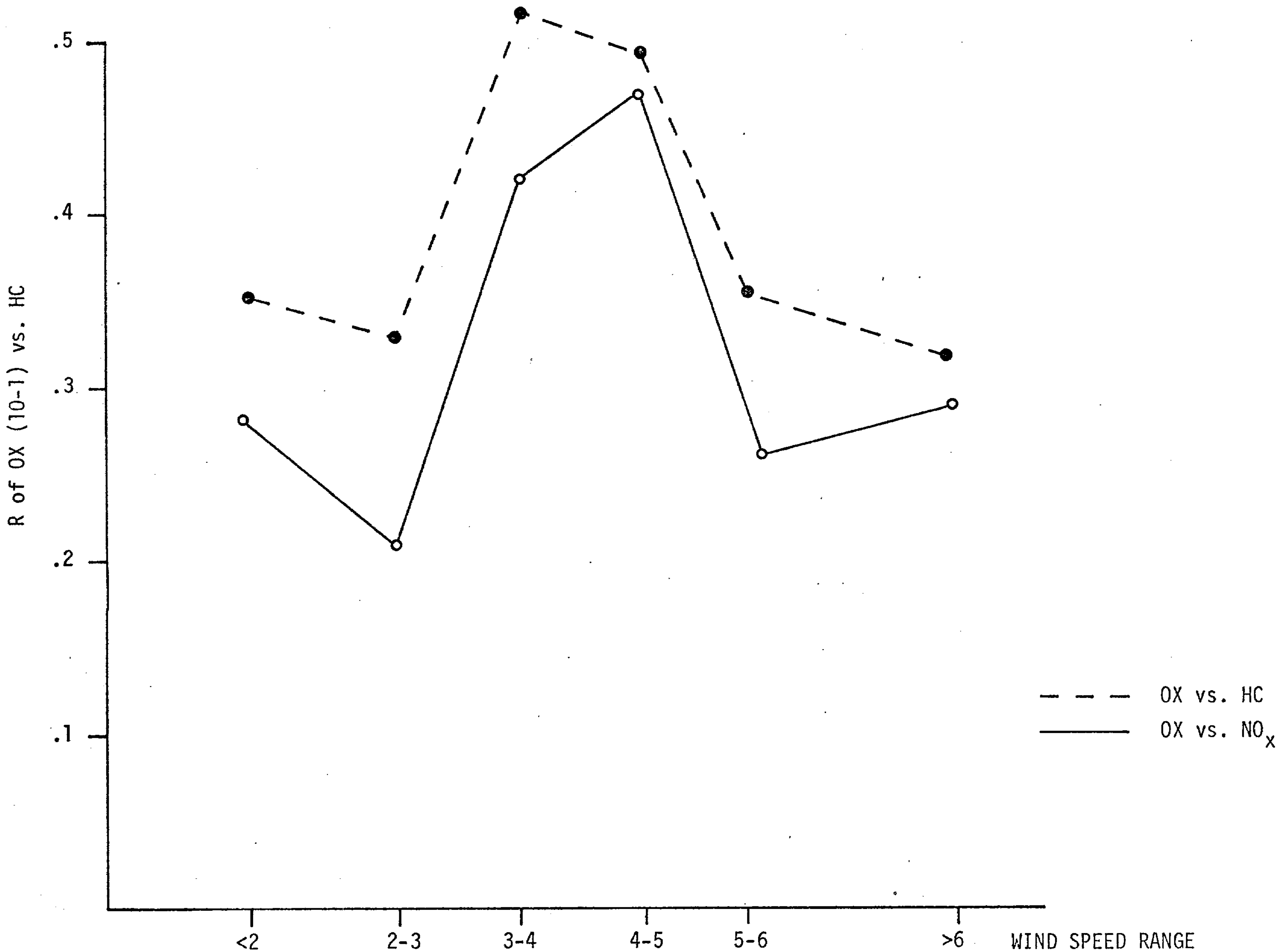

Figure 2.2. Correlation Coefficient of OX 10-1 versus HC and NO_x as a Function of Wind Speed

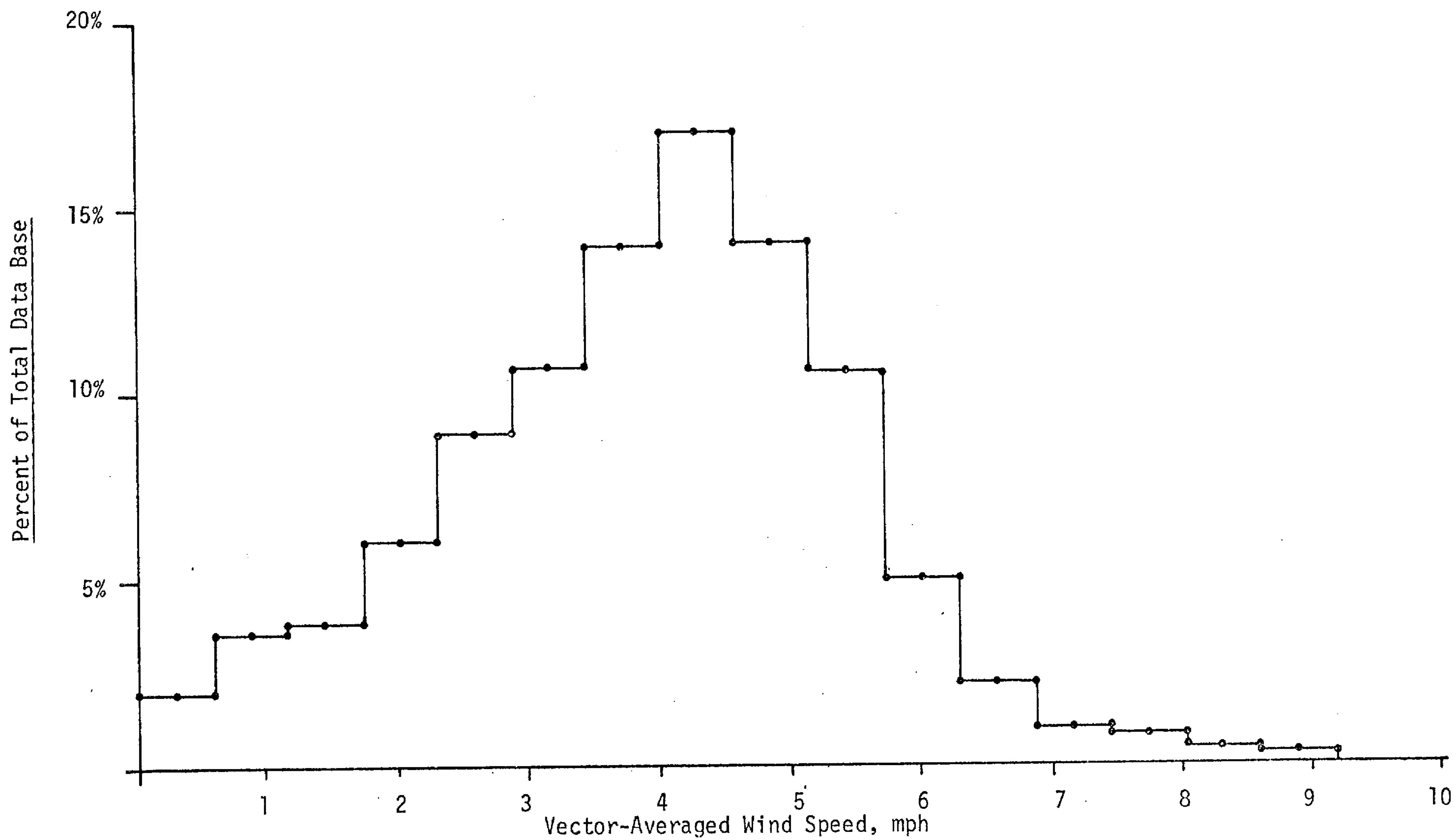

Figure 2.3. Histogram of Average Wind Speeds at DOLA (7 AM to 2 PM).

It is interesting to note that the oxidant/hydrocarbon relationship is strongest at moderate, typical wind speeds, and that the correlation between these pollutants falls off at both high and low wind speeds. The "low average wind speed" category includes not only calm days but also days on which the wind speed was moderate but the direction reversed during the forenoon. On the latter days, regions surrounding downtown Los Angeles can exert a significant influence on the oxidant level at DOLA, weakening the correlation between DOLA oxidant and local hydrocarbon emissions.

On days with high wind speeds, both oxidant and hydrocarbon levels tend to be low. To the extent that both oxidant and hydrocarbons may be correlated with wind speed and mixing height, some mutual correlation between oxidant and local hydrocarbons at high wind speeds is anticipated. The high wind speed category also includes steady Santa Ana (easterly) wind flows, in which DOLA tends to experience later-than-normal oxidant peaks under the influence of upwind precursors. Since both these upwind hydrocarbons and the local DOLA hydrocarbons will show a correlation with wind speed, and since the upwind hydrocarbons should correlate fairly well with afternoon DOLA oxidant, one would expect the afternoon DOLA oxidant concentrations to correlate fairly well with local DOLA hydrocarbon levels. This is in spite of the fact that there is no direct cause-and-effect link between the DOLA morning hydrocarbons and afternoon oxidants, since they are in different air masses under strong wind conditions.

One possible objection to the use of days with 3-5 mph average wind speed is that, even with this moderate wind flow, the morning hydrocarbon and afternoon oxidant measurements are made on different air masses. However, in this study the 6-9 AM average precursors and the 10-1 PM average oxidant levels will be used; under these conditions, the precursor and oxidant readings would be made on air masses perhaps 16 miles apart. Since at any instant oxidant tends to be a slowly varying function of geographic position, the afternoon DOLA oxidant reading may characterize the afternoon oxidant level of the DOLA morning air mass fairly well. Also, since wind speeds in the SCAB tend to increase from morning to afternoon, the average wind speed for the period 6 AM to 11 AM will generally be lower than the average for 6 AM to 2 PM. Therefore, the use of DOLA morning hydrocarbon with DOLA mid-day oxidant levels and wind speeds of 3-5 mph can be justified.

2.3 RELATIONSHIP OF PEAK OXIDANT TO 10-1 AVERAGE OXIDANT

The foregoing discussion has centered on the relationship between morning hydrocarbons and 10-1 (3-hour average) oxidant. In many applications, the peak 1-hour average oxidant level may be of greater interest. However, because it is based on a single measurement instead of the average of three readings, this quantity is less reliable (statistically, less "robust") than the 10-1 average. Therefore, we believe that the 10-1 average oxidant at DOLA can be modeled more accurately than the daily maximum one-hour oxidant level. This assertion is supported by the fact that the oxidant/hydrocarbon correlation coefficient of the 10-1 oxidant is somewhat greater than that of the daily maximum hourly average oxidant (.43 versus .39).

We expect that 10-1 oxidant and daily maximum oxidant should be reasonably well correlated. The regression of OX MAX (daily maximum one-hour oxidant average) versus OX 31 (10-1 average oxidant) yields a very respectable correlation coefficient of .82. The equation obtained through linear regression is:

$$OXMAX = .029\ ppm + 1.25\ OX31 \quad \text{(all readings in ppm)}$$

Using this equation, one can reliably estimate the daily maximum one-hour average oxidant value from the 10 AM to 1 PM three-hour average.

2.4 MORNING WIND REVERSAL PATTERN

Some 30% of the days in the data base fit a pattern in which the early morning wind is easterly, while the late morning wind is westerly. On such days the air mass near DOLA at 7 AM will tend to be transported to the west and then to the east, returning to DOLA in the late morning or early afternoon. The two to six hour time period of this cycle is sufficient to permit a fairly thorough conversion of the precursors into oxidant. Since the oxidant formed during this wind pattern develops from early morning DOLA precursors, one would anticipate a high correlation between DOLA oxidant and DOLA precursors on days exhibiting this wind pattern. However, as Table 2.1 indicates, the oxidant-precursor correlation is actually weaker than average during wind reversal days.

Since the oxidant-hydrocarbon and oxidant-NO_x correlation coefficients for days of average wind speed 3-6 mph (with or without wind reversal) are consistently higher than those for days exhibiting wind reversal, it is clear that the former set of days is more appropriate for the present study.

3.0 "SCENARIO II": EARLY AFTERNOON OXIDANT FROM SHORT-DISTANCE TRANSPORT

This "Scenario" will attempt to model the formation of oxidant at DOLA, Pasadena, and Burbank from morning precursors at DOLA. The predominant westerly-southwesterly wind flow of the SCAB tends to push air from DOLA eastward toward Pasadena and northward across the Santa Monica Mountains to Burbank. (See Figure 3.1.) The wind flow curves around the mountains, becoming southeasterly at Burbank. Over 50% of all days exhibit this wind pattern.

Because of the time required for transport of air from DOLA to Burbank and Pasadena, oxidant peaks at these receptor sites tend to occur somewhat later than those at DOLA. Therefore, oxidant readings corresponding to 11-12 AM, 12-1 PM , 1-2 PM, and 2-3 PM were chosen for this study. These times are late enough in the day to permit the formation of high oxidant levels at the receptor sites but early enough to minimize the influence from upwind sources other than DOLA.

3.1 COMPILATION OF DATA BASE FOR SCENARIO 2

The data base for this scenario includes the following air quality data: 1) the 11-12 AM, 12-1 PM, 1-2 PM, and 2-3 PM one-hour average oxidant concentrations at DOLA, Pasadena, and Burbank; 2) the average of the 6-7, 7-8, and 8-9 AM one-hour hydrocarbon levels at DOLA; and 3) the average of the 6-7, 7-8, and 8-9 NO_x values at DOLA. These oxidant averaging times were chosen because the Pasadena oxidant peak is usually reached by early afternoon during the summer and because a southwesterly wind averaging 3-4 mph will carry air from DOLA to Pasadena in 3-4 hours. Various 2,3, and 4-hour averages of the oxidant levels were also computed and included for analysis.

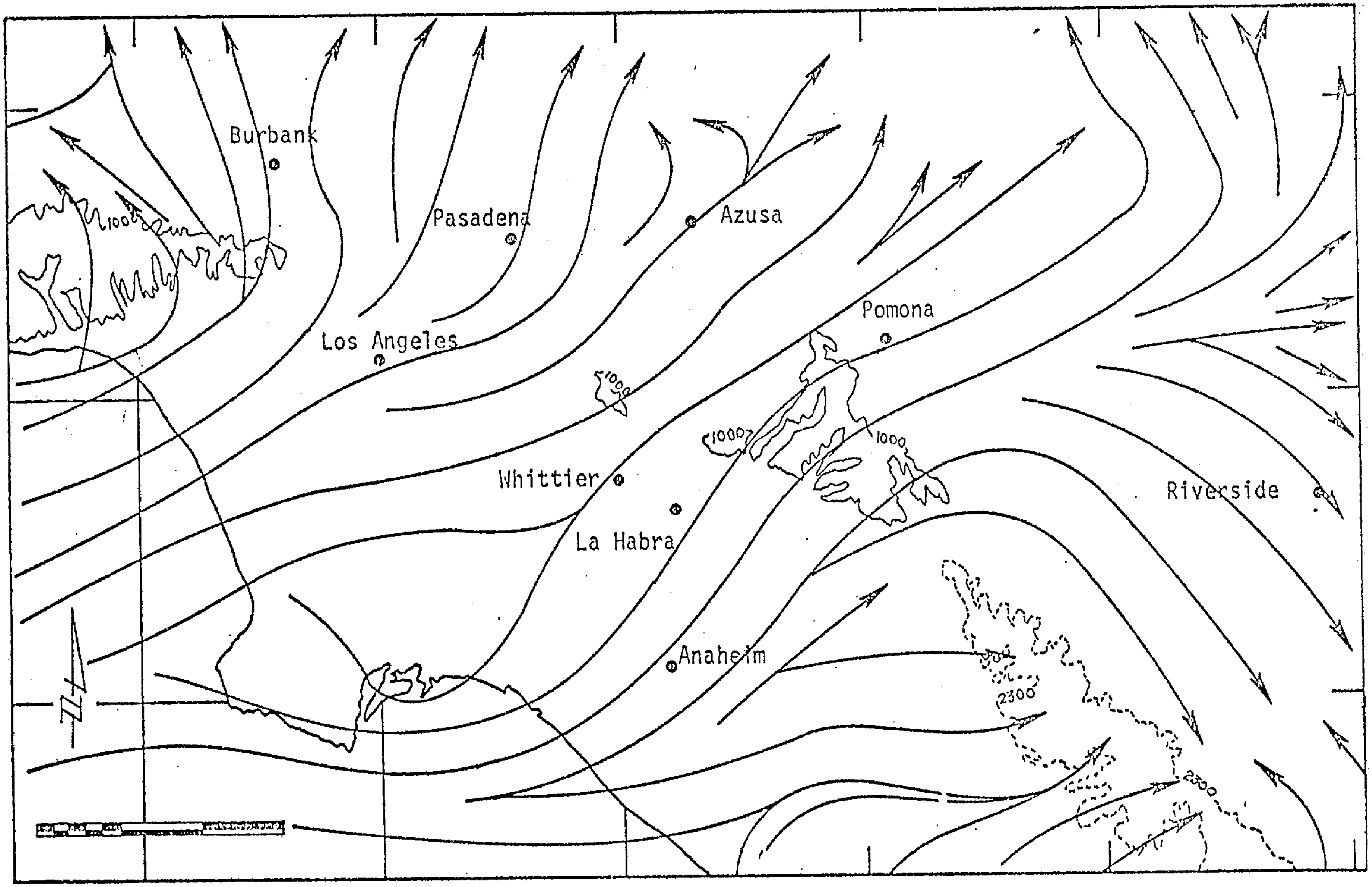

Figure 3.1 Streamlines of Most Frequent Surface Winds During July.

These air quality data were supplemented by the following meteorological data: 1) 7 AM through 1 PM hourly wind speeds and directions at Burbank and at DOLA; 2) the midday average and daily maximum temperatures at Burbank and at DOLA; 3) the midday average solar radiation at DOLA; 4) the calculated daily maximum mixing height at DOLA; 5) the daily maximum temperature at Mt. Wilson; and 6) the morning temperature profile at LAX. Although only the wind data will be used in the preliminary study, the other meteorological data will be needed in the model development of Phase III.

Because the wind flow at DOLA must be from the southwest quadrant for transport to Pasadena and Burbank to occur, the Scenario II study is limited to days with wind flow from SSE through WNW, an interval slightly larger than this quadrant. Figure 3.2, a histogram of DOLA wind directions, demonstrates that the restriction of the data base to days with wind directions SSE through WNW still leaves a large enough data base for model development. Therefore, all Scenario II modeling and discussion will involve only days exhibiting a DOLA average wind direction in this range.

3.2 PRELIMINARY ANALYSIS OF OXIDANT-PRECURSOR RELATIONSHIP

As in Scenario I, we performed a series of oxidant-hydrocarbon and oxidant-NO_x regressions, covering ten different oxidant averaging periods. Table 3.1 and Figure 3.3 illustrate the relationship between oxidant-precursor correlations and oxidant averaging times for each of the three receptor stations and each of the two precursor pollutants. Oxidant-hydrocarbon correlations are consistently stronger than oxidant-NO_x correlations and Pasadena oxidants show the best correlations to precursors, DOLA the

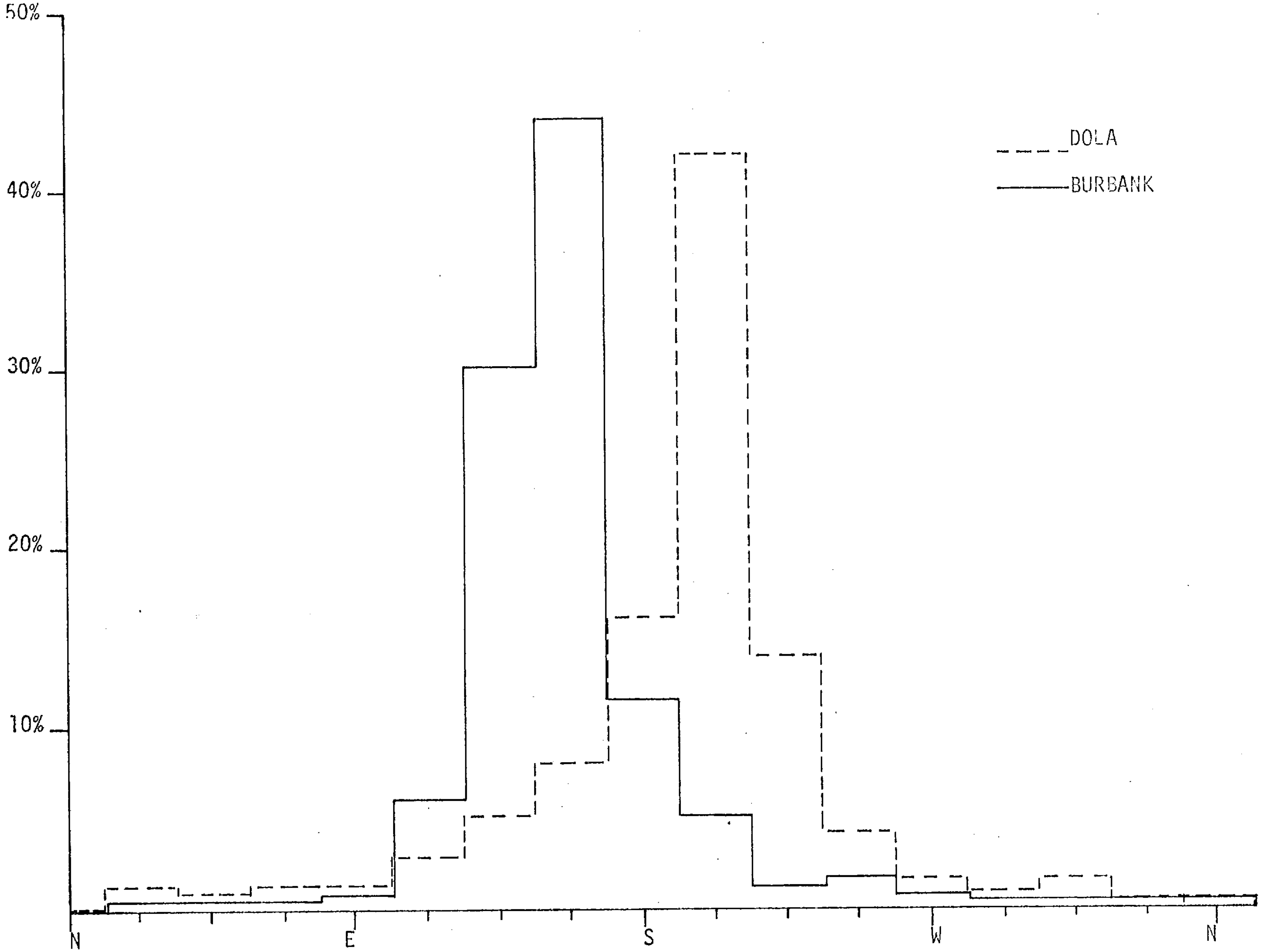

Figure 3.2 Histograms of Wind Directions at DOLA and Burbank

Table 3.1 Correlation Between Oxidant at DOLA, Burbank, Pasadena and HC and NO_x at DOLA*

	11-12 OX	11-1 OX	12-1 OX	11-2 OX	12-2 OX	11-3 OX	12-3 OX	1-2 OX	1-3 OX	2-3 OX
Hydrocarbons										
DOLA	0.44	0.42	0.38	0.41	0.38	0.39	0.36	0.35	0.32	0.27
Burbank	0.45	0.47	0.46	0.45	0.44	0.42	0.40	0.40	0.36	0.30
Pasadena	0.50	0.50	0.48	0.50	0.49	0.49	0.48	0.48	0.45	0.40
NO_x										
DOLA	0.36	0.35	0.32	0.34	0.31	0.32	0.29	0.29	0.25	0.20
Burbank	0.33	0.35	0.34	0.34	0.34	0.32	0.30	0.32	0.27	0.21
Pasadena	0.37	0.36	0.34	0.36	0.35	0.36	0.35	0.34	0.34	0.32

*Wind direction at DOLA between WNW and SSE

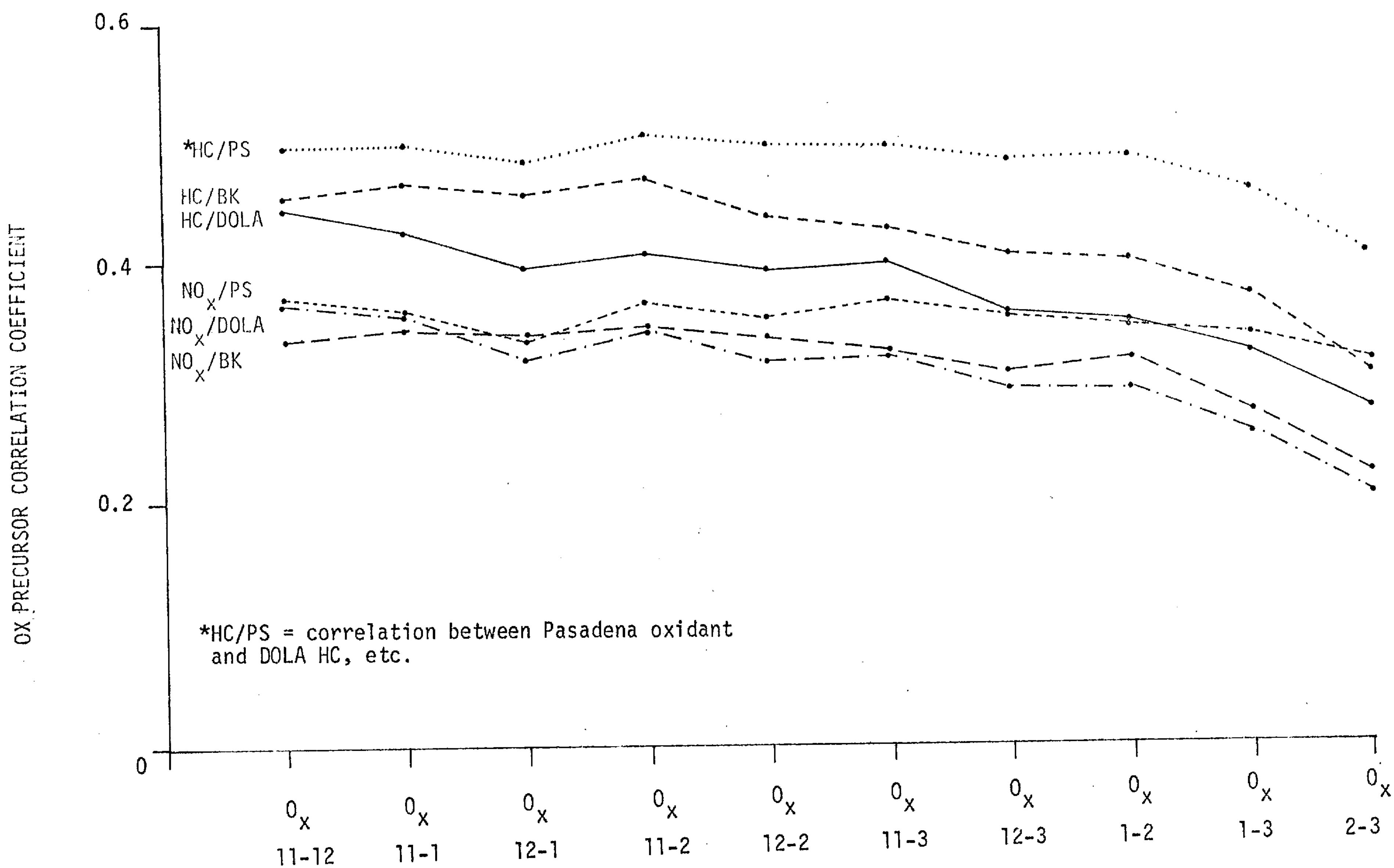

Figure 3.3 OX-Precursor Correlations as a Function of OX Averaging Period

worst. Since the three-hour oxidant average, 11-2 PM, yields the highest oxidant-precursor correlations, we will use that oxidant averaging time for the remainder of this analysis.

Because of the spatial separation between the source and the receptor sites in this study, we anticipated that the best oxidant-hydrocarbon correlations would be obtained with moderate to average wind speeds at DOLA, perhaps 4 or 5 mph. Table 3.2 lists the oxidant-precursor correlation coefficients for data subsets corresponding to various choices of DOLA wind speed. When only days with an average DOLA wind speed of less than 3 or greater than 5 mph are considered, the correlations are substantially lower than those when days with 3-5 mph or 3-6 mph wind speeds are used. On the basis of these correlations, it was decided that the study would be further restricted to days having not only a DOLA average wind direction between WNW and SSE, but also an average DOLA wind speed of 3-6 mph.

The next statistical test was to determine the effect of Burbank wind speed on the correlation between Burbank oxidant and DOLA precursors. The purpose was to ascertain whether restrictions on Burbank wind speed should be used in developing the model. Table 3.3 shows the relative insensitivity of the correlation coefficients to Burbank wind speed. Predictably, the lowest Burbank wind speeds yield somewhat poorer correlations than the average and higher wind speeds. Because of the relatively small number of days exhibiting these very low wind speeds (under 3 mph), we will not sort the data base by Burbank wind speed in this scenario.

Theoretically, one should also consider sorting the data base by Burbank wind direction. However, as shown in Figure 3.2, nearly 95% of the

Table 3.2 OX-Precursor Correlations versus DOLA Wind Speed

	DOLA OX 11-2		Pasadena OX 11-2		Burbank OX 11-2		
	HC	NO_x	HC	NO_x	HC	NO_x	N*
WS<3	.18	.14	.25	.15	.10	.03	100
3≤WS≤5	.47	.39	.61	.50	.53	.49	300
3≤WS≤6	.46	.38	.58	.48	.54	.48	400
WS≥5	.31	.21	.50	.38	.53	.42	150

*N = number of cases

denotes insignificant correlation

Table 3.3 Burbank 3-Hour Oxidant/DOLA Precursor Correlations versus Burbank Wind Speed*

	BURBANK AVERAGE WIND SPEED					
	<3 mph	3-5 mph	3-6 mph	4-6 mph	4-7 mph	>5 mph
Precursor						
HC	.40	.50	.52	.48	.50	.55
NO_x	.25	.48	.49	.47	.49	.50
Number of Cases	35	110	170	135	185	140

Conditions: DOLA wind direction from southwest quadrant
DOLA wind speed 3-6 mph
Burbank wind direction from southeast quadrant

days have Burbank average winds from the southeast quadrant, the proper direction for the current study. Sorting according to wind direction at Burbank resulted in no improvements in the oxidant/precursor correlations. Therefore, it was decided that neither Burbank wind speed nor Burbank wind direction data would be used in this scenario.

We decided not to conduct a similar study study of Pasadena wind data for two reasons: 1) Pasadena wind data are available only in hand written form and would have to be collected and keypunched for use in the study; and 2) the insensitivity of oxidant-precursor correlations to Burbank wind data indicates that a study with Pasadena wind data might not be particularly valuable in model development.

Since this study involves three receptor sites, DOLA, Burbank, and Pasadena, the next step was to develop a single parameter, OX*, which would best characterize the receptor oxidant level under various conditions. This variable will become the dependent variable for the model development of Phase III. The variable should reflect DOLA oxidant for days with low wind speeds, Burbank oxidant for days with a strong southerly wind, Pasadena oxidant for days with a strong westerly wind, and various combinations of these for winds between these patterns.

The initial development of OX^* proceeded as follows. Only days with DOLA wind speeds of 3-6 mph were considered and only the three hour (11-2 PM) oxidant averages were used. For days with DOLA average wind speed below a chosen threshold, OX^* was set equal to the DOLA oxidant value, while for wind speeds above the threshold, OX* was set equal to the average of the Burbank and Pasadena oxidants. Five threshold wind speeds from 3 to 5 mph were tested. As Figure 3.4 illustrates, the best correlations were obtained with a threshold of 3 mph. However, since all days with DOLA average wind speeds below 3 mph were already excluded from the data base, a threshold of 3 mph actually corresponds to the elimination of DOLA oxidant as part of the dependent variable.

The foregoing statistical study used only the arithmetic average of the Burbank and Pasadena oxidant values. The next step was to determine the optimal weighting between the two. On physical grounds, it appears that southerly winds at DOLA should lead to higher Burbank oxidant/DOLA precursor correlations, while westerly winds should give higher Pasadena oxidant/DOLA precursor correlations. The first test was to divide the southwest quadrant at various compass points. For all days with DOLA wind directions south or east of a given point, OX* was set equal to the Burbank oxidant. For days with winds west of the dividing point, OX* was set equal to the Pasadena oxidant level, while for days with average wind at the dividing point, OX* was the average of the Pasadena and Burbank oxidants. Figure 3.5 and Table 3.4 show the effect of the choice of partition direction on the oxidant-precursor correlation coefficients. Best results are obtained for a SSW partition, i.e., one for which S and SSE winds are assumed to carry DOLA precursors to Burbank, while SW, WSW, W, and WNW winds are assumed to go to Pasadena. Since Burbank lies to the NNW and Pasadena to the NE of DOLA, this partition seems physically reasonable. (See Figure 3.1.)

Two further tests were tried. First, a more gradual ("soft") transition between Burbank and Pasadena oxidant was used, in which wind directions adjacent to the partition direction were assigned to 75%-25% and 25%-75% blends of

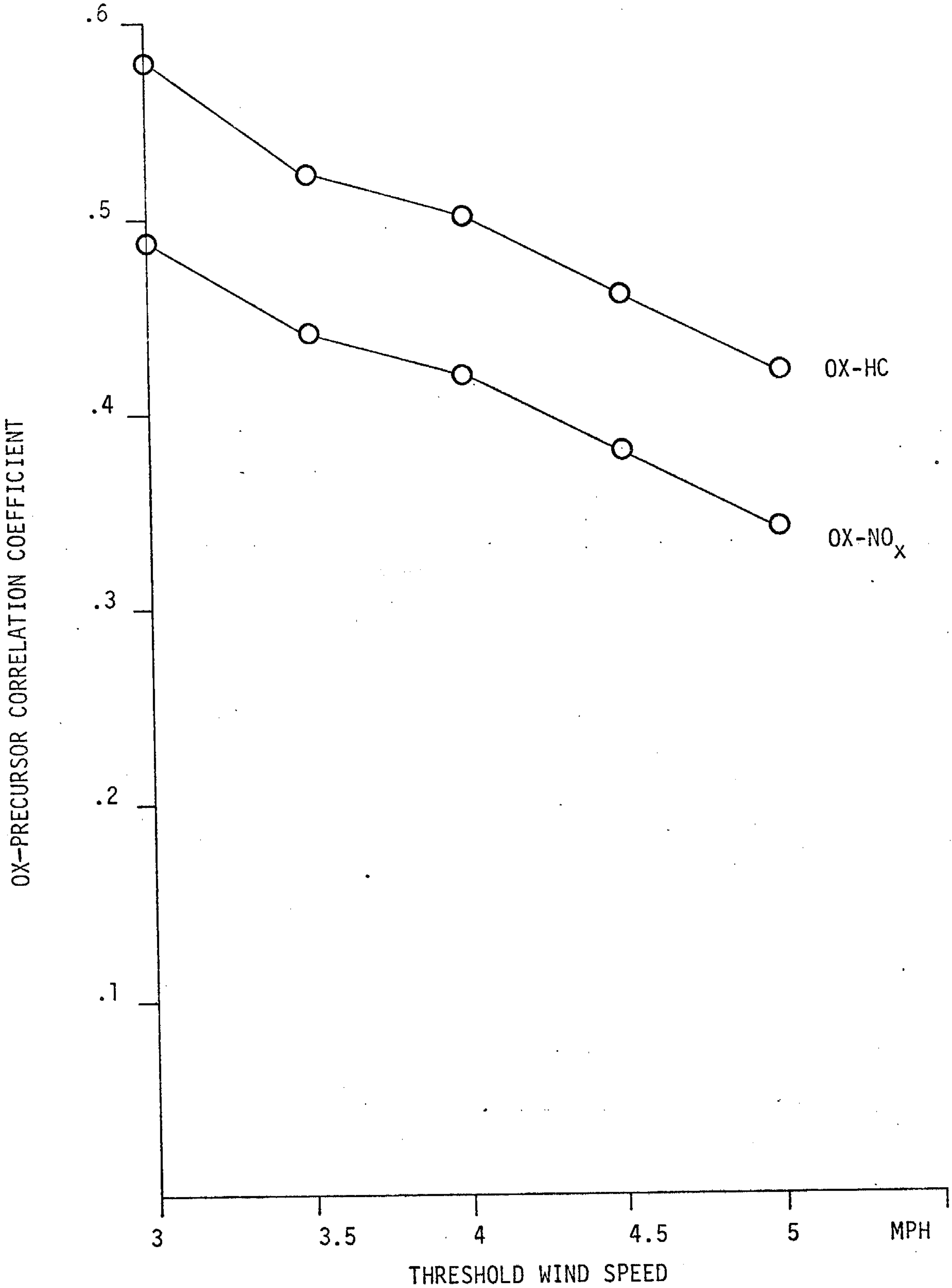

Figure 3.4 Relationship Between OX-HC and OX-NO_x Correlation Coefficients and Threshold Wind Speed for Excluding DOLA Oxidant Data

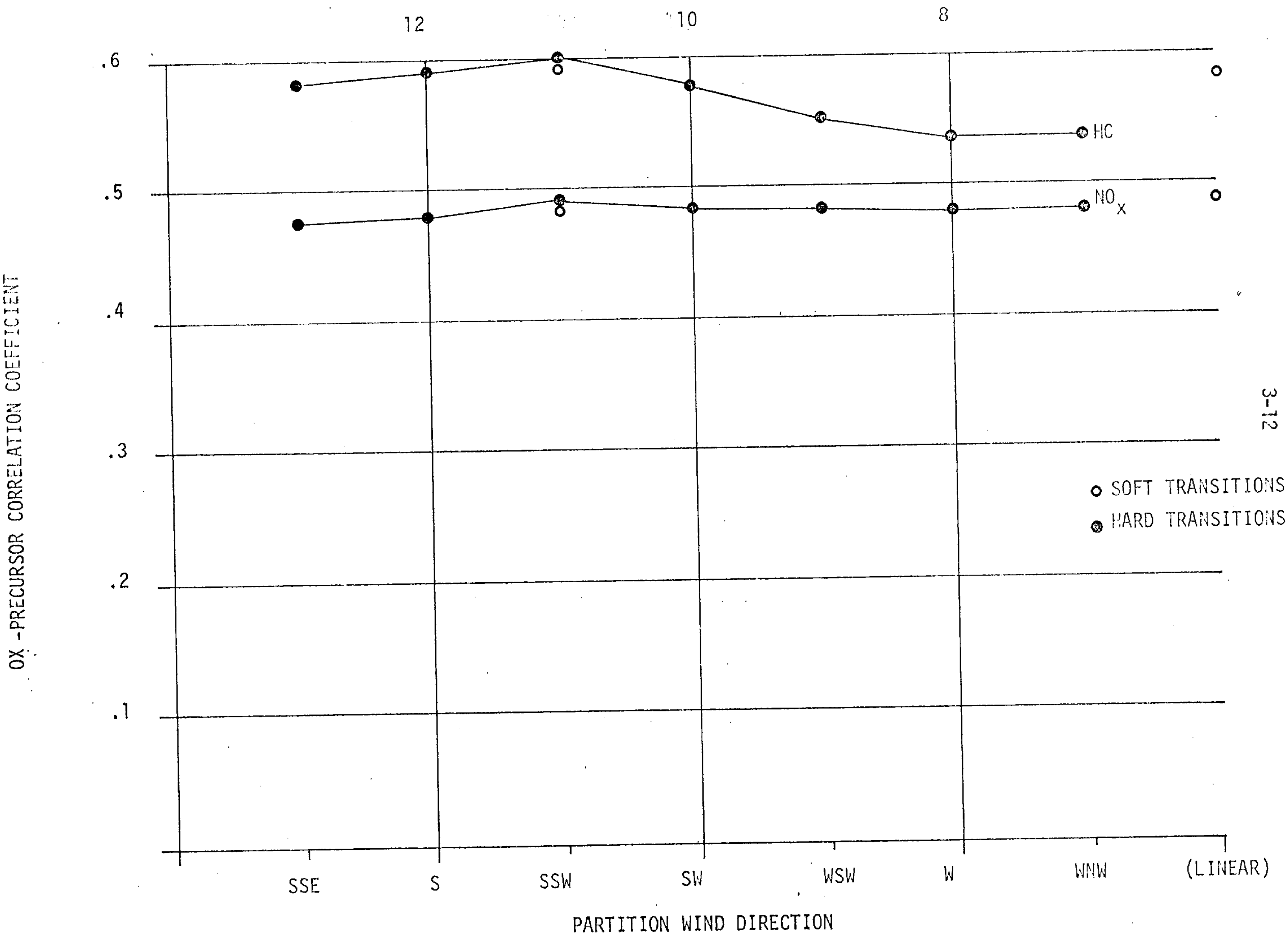

Figure 3.5 Impact of Burbank-Pasadena Oxidant Partition on OX-HC and OX-NO_X Correlation

Table 3.4 Impact of Burbank - Pasadena Oxidant Partition on Oxidant - Precursor Correlations

Partition Wind Direction (DOLA Average Wind)*

	SSE	S	SSW	SW	WSW	W	WNW
OX-HC	.58	.59	.60	.58	.55	.54	.54
OX-NO_x	.48	.48	.49	.49	.48	.48	.48

Correlations for "Soft" Burbank-Pasadena Transitions**

	SSW	LINEAR
OX-HC	.60	.59
OX-NO_x	.49	.49

*Oxidant for wind in partition direction = average of Pasadena and Burbank oxidant.

Oxidant for wind west of partition = Pasadena oxidant

Oxidant for wind east of partition = Burbank oxidant

**"Soft" transitions defined later in text.

Pasadena and Burbank oxidants. The oxidants at the other directions were left the same as before. The overall correlation coefficients were slightly, though not significantly, lower, as shown in Table 3.4 and Figure 3.5.

The final test used a linear partitioning function, in which OX^* was defined as follows:

For Wind Direction:	OX^* Equals:
SSE	Burbank Oxidant (B)
S	(5B + P)/6
SSW	(4B + 2P)/6
SW	(B + P)/2
WSW	(2B + 4P)/6
W	(B + 5P)/6
WNW	Pasadena Oxidant (P)

This linear case showed slightly weaker oxidant-precursor correlations than the sharp partition at SSW.

The results of this preliminary statistical analysis indicate that the "Scenario" 2 model should be based on days having DOLA wind directions in or near the southwest wind quadrant and DOLA wind speeds 3-6 mph. We will use Pasadena oxidant for winds west of SSW, Burbank oxidant for winds east of SSW, and the average of Burbank and Pasadena oxidant for winds from the SSW. The oxidant-hydrocarbon correlation resulting from these choices, .6, is trong enough to make a modeling effort appear feasible.

3.3 RELATIONSHIP OF PEAK OXIDANT TO THREE-HOUR AVERAGE OXIDANT

Since Scenario I involves only a single oxidant receptor site, its write-up included a discussion of the relationship between the daily maximum one-hour average oxidant at that site and the three-hour average oxidant that will be used in development of the model. In Scenarios 2 through 5, which have multiple receptor sites, a linear combination of oxidant values will be used for model development. When the final model is developed in Phase 3, the 3-hour oxidant combinations used in its development will be related to the peak oxidant levels at all receptor sites studied. When this is done, it will be possible to relate peak oxidant as well as three-hour oxidant to the morning precursors. As discussed previously,the oxidant-precursor correlation is expected to be stronger for the 3-hour average oxidant than for the 1-hour average, due to the greater statistical robustness of the former.

4.0 "SCENARIO III": MID-AFTERNOON OXIDANT AFTER MODERATE-RANGE TRANSPORT

This scenario examines morning hodrocarbons and afternoon oxidants at moderately separated source and receptor sites in the SCAB. The candidate source sites for algorithm development are DOLA, Whittier, and Lennox. Other sites in the vicinity of these sources will not be used, due to a shortage or absence of hydrocarbon data. The receptor sites will be selected among Upland, Pasadena, Azusa, and Pomona, as these sites usually are downwind of the source sites and should be heavily influenced by them. The first of these is a California Air Resources Board monitoring site established in 1972; the others are Southern California AQMD sites established before 1971.

4.1 COMPILATION OF DATA BASE FOR SCENARIO 3

As in the previous scenarios, this study was limited to the months May through October, for the years 1971 through 1975. All days covered by these five six-month periods were initially included in the data base. As the study progressed, incresingly stringent data completeness and meteorological constraints were placed on the data, reducing somewhat the total number of data points for algorithm development.

Air quality data in the Scenario 3 data base comprised: (1) each day's average of the 6-7, 7-8, and 8-9 AM hydrocarbon readings at DOLA, at Whittier, and at Lennox; (2) the average of the 6-7, 7-8, and 8-9 AM NO_x levels at these sites; and (3) the 12-1, 1-2, 2-3, and 3-4 PM hourly oxidant concentrations at Pomona, Azusa, Upland (ARB), and Pasadena. The later hours for oxidant were used because of the longer source-to-receptor transport of this scenario.

Meteorological data comprised: (1) 7 AM through 2 PM hourly wind speeds and directions at LAX, DOLA, Ontario, and Long Beach; (2) mid-day average temperatures and daily maximum temperatures at DOLA, Ontario, and LAX; (3) midday average solar radiation at DOLA; (4) Mt. Wilson daily maximum temperature; (5) measured vertical temperature profiles at LAX; and (6) calculated daily maximum mixing heights at DOLA. All of these data were collected from various ARB and APCD tapes for use in the preliminary statistical analysis and in the development of the final oxidant-precursor model in Phase III.

4.2 PRELIMINARY ANALYSIS OF OXIDANT-PRECURSOR RELATIONSHIP

The first statistical test performed was the computation of correlations between oxidant levels at the four receptor sites and precursor concentrations at the three source sites. As in earlier studies, four consecutive hourly oxidant levels and various two, three, and four averages of these were used as dependent variables in the correlation.

Table 4.1 lists the correlations between various oxidant and precursor levels. Because of the uniformly poor correlations obtained with both precursors at Lennox, that station will be deleted from all further studies of this scenario.

To increase the low correlations between oxidants and morning precursors is the primary goal of this preliminary site selection and data stratification study. The various wind speed direction stratifications and linear combinations of sources and of receptors used to attempt to maximize these correlations are the subject of the remainder of this chapter.

Table 4.1 Scenario 3 - Summary of Correlation Coefficients

Precursor		OX 12-1	OX 1-2	OX 2-3	OX 3-4	OX 12-2	OX 1-3	OX 2-4	OX 12-3	OX 1-4	OX 12-4
		Oxidant Averaging Time:									
PASADENA											
DOLA	NOX	.31	.29	.25	.18	.30	.27	.22	.29	.25	.27
WHT	NOX	.22	.17	.12	.05	.20	.15	.09	.18	.12	.15
LEN	NOX	-.05	-.03	-.01	-.02	-.04	-.02	-.01	-.03	-.02	-.03
DOLA	HC	.44	.42	.34	.24	.44	.40	.30	.42	.36	.39
WHT	HC	.34	.26	.20	.10	.30	.24	.15	.28	.20	.24
LEN	HC	.02	.04	.07	.04	.03	.06	.06	.05	.06	.05
POMONA											
DOLA	NOX	.12	.12	.08	.05	.12	.10	.07	.11	.09	.10
WHT	NOX	.01	.00	-.01	-.01	.01	-.00	-.01	-.00	-.01	-.00
LEN	NOX	-.16	-.17	-.17	-.14	-.17	-.18	-.16	-.17	-.17	-.17
DOLA	HC	.24	.26	.20	.13	.25	.23	.17	.24	.20	.22
WHT	HC	.10	.10	.08	.06	.10	.09	.07	.10	.08	.09
NEG	HC	-.09	-.11	-.10	-.06	-.10	-.10	-.08	-.10	-.09	-.09

Not a statistically significant correlation

Table 4.1 Scenario 3 - Summary of Correlation Coefficients (Cont'd.)

Precursor		Oxidant Averaging Time: OX 12-1	OX 1-2	OX 2-3	OX 3-4	OX 12-2	OX 1-3	OX 2-4	OX 12-3	OX 1-4	OX 12-4
						AZUSA					
DOLA	NOX	.21	.21	.20	.18	.21	.20	.19	.21	.20	.21
WHT	NOX	.12	.13	.11	.07	.13	.12	.09	.12	.10	.11
LEN	NOX	-.11	-.13	-.10	-.06	-.12	-.12	-.08	-.12	-.10	-.11
DOLA	HC	.37	.37	.33	.28	.38	.36	.32	.37	.34	.36
WHT	HC	.22	.23	.18	.13	.23	.21	.16	.22	.19	.20
LEN	HC	-.04	-.05	-.02	-.02	-.04	-.04	-.00	-.04	-.02	-.02
						UPLAND					
DOLA	NOX	.04	.02	.03	.05	.03	.03	.04	.03	.04	.04
WHT	NOX	.04	.01	.03	.06	.02	.02	.04	.03	.03	.04
LEN	NOX	-.10	-.10	-.10	-.08	-.10	-.10	-.09	-.10	-.09	-.10
DOLA	HC	.27	.25	.24	.30	.26	.26	.29	.27	.28	.28
WHIT	HC	.02	-.01	.00	.05	.00	-.00	.03	.00	.01	.02
LEN	HC	.02	.02	.02	.06	.02	.02	.04	.02	.03	.03

The correlation coefficients in Table 4.1 apply to all days in the data base, without regard to wind speed or direction or other meteorological variables. The next step was to repeat the oxidant-precursor regressions for various subsets of the days in the data base. The oxidant values chosen for the study were the first three-hour averages (OX 12-3), because of the statistical robustness of 3-hour oxidant averages and because the correlations between the OX 12-3 averages and the precursors are consistently higher than those of OX 1-4 or OX 12-4.* The objective of this portion of the study then is to maximize the correlations between these three-hour oxidant values and the hydrocarbon and NO_x precursor concentrations through appropriate restrictions on wind speeds and wind directions and choices of monitoring stations.

The first data base stratification was to restrict the vector average DOLA wind direction to the southwest quadrant, directions South through West, inclusive. This restriction was made primarily on physical grounds, i.e., wind must be from the southwest quadrant in order for the transport of air from the sources to the receptors to occur. We anticipated that this restriction would enhance the various oxidant-precursor correlation coefficients by eliminating days with winds in the "wrong" direction, e.g., from receptor to source. The correlations between the OX 12-3 three-hour average and the morning precursors for the various sites are listed in Table 4.2. The first entry in each square in the table is the correlation

*An exception is Upland, whose OX 1-4 and OX 12-4-hydrocarbon correlations are slightly stronger than those of OX 12-3. For consistency, however, the Upland OX 12-3 value will be used.

Table 4.2 Correlation Between 12-3 PM Oxidant and 6-9 AM Precursors Without and With DOLA Wind Direction Restriction.

Precursor	POM-OX	AZU-OX	UPL-OX	PAS-OX
DOLA NOX	.11/.15	.21/.21	.03/.14	.29/.26
WHT NOX	.00/.10	.12/.14	.03/-.02	.18/.17
DOLA HC	.24/.40	.37/.43	.27/.22	.42/.46
WHT HC	.10/.19	.22/.18	.00/-.01	.28/.23

First entry in each box is correlation <u>without</u> wind direction restriction based on ≈600 data points.

Second entry is correlation <u>with</u> wind direction restriction, based on ≈ 400 data points.

Significant corelation at 95% confidence level is approximately $2/\sqrt{N}$, where N = number of cases.

Here, $2/\sqrt{600} = .08$
$2/\sqrt{400} = .1$

Not significant for the sample size.

coefficient obtained when all days are included in the data base; the second is the correlation coefficient obtained when only days with southwesterly winds are included. Because the wind direction sort reduces the already weak oxidant-hydrocarbon correlations at Upland, we decided to delete that site from the list of potential receptor sites for model development. This decision reflects the fact that the Upland data base is somewhat limited (a total of 250 days for the 5-year period) and that the Upland oxidant levels appear to be sensitive to influences other than the hydrocarbon and NO_x levels at our chosen precursor monitor sites.

Next we tried sorting the data base by average DOLA wind speed. Four restrictions were tested: DOLA wind speed greater than 3 mph; DOLA wind speed greater than 4 mph; DOLA wind speed 3-6 mph; and DOLA wind speed 4-7 mph. The correlation coefficients corresponding to these wind speed restrictions are listed in Table 4.3. The continued weakness of correlations between Upland oxidant and the various precursors supports the earlier decision to omit that site from further study. Not surprisingly, the restriction of DOLA wind speeds to 4 mph and higher yields the strongest oxidant-hydrocarbon correlation coefficients. Since the average source-receptor separation in this scenario exceeds 20 miles, winds below 4 mph incapable of transporting air from the source sites to the receptor sites within the few hours between 6-9 AM and 12-3 PM.

With the data base restricted to days with southwesterly DOLA winds of over 4 mph, and with the Lennox and Upland sites eliminated, the oxidant-precursor correlations are high enough to justify continuing the study of this scenario. Interestingly, these correlations are further strengthened

Table 4.3 Effect of DOLA Wind Speed and Direction* Restrictions on Oxidant-Precursor Correlation Coefficients

	DOLA WIND SPEED ≥ 3 mph				DOLA WIND SPEED ≥ 4 mph			
	Receptor Site				Receptor Site			
Precursor	POM	AZU	UPL	PAS	POM	AZU	UPL	PAS
DOLA NO_x	.15	.22	.14	.27	.21	.27	.19	.32
WHT NO_x	.10	.14	-.02	.17	.17	.20	.05	.22
DOLA HC	.40	.43	.22	.46	.42	.44	.25	.48
WHT HC	.19	.19	-.01	.24	.28	.25	.08	.28

	DOLA WIND SPEED 3-6 mph				DOLA WIND SPEED 4-7 mph			
DOLA NO_x	.12	.19	.11	.24	.19	.25	.18	.31
WHT NO_x	.08	.12	-.05	.16	.16	.18	.05	.21
DOLA HC	.39	.43	.21	.45	.40	.42	.24	.46
WHT HC	.18	.18	-.03	.23	.27	.24	.08	.27

	DOLA WIND SPEED ≥ 4 mph (Upland removed from data base)		
	POM	AZU	PAS
DOLA NO_x	.25	.33	.37
WHT NO_x	.25	.29	.28
DOLA HC	.37	.46	.48
WHT HC	.33	.36	.36

*DOLA Wind Direction Restricted to Southwest Quadrant (South through West, inclusive) for all cases.

Number of data points in regression ≈ 400.

Not statistically significant at 95% confidence level.

by the removal of Upland from the data base, as shown in the last portion of Table 4.3. This removal allows days with missing Upland oxidant data to be included in the data base. Therefore, it appears that days without Upland oxidant data tended, by coincidence, to have "better" oxidant-precursor relationships than did the days with Upland oxidant data.

The next steps in the analysis involved constructing new variables from linear combinations of the oxidants and of the precursors of the various sites. First, a new series of dependent variables was defined, each of which was a wind-dependent linear combination of Pomona, Azusa, and Pasadena oxidants. These new dependent variables were regressed against the DOLA and Whittier precursors. Next, a new series of independent variables was defined, each of which was a wind-dependent linear combination of the DOLA and Whittier hydrocarbons or NO_x. The Pomona, Azusa, and Pasadena oxidants were regressed against these. Finally, several promising linear combination oxidants were regressed against some candidate linear combination hydrocarbons and NO_x. This series of regressions is the subject of the following paragraphs.

First, we defined various linear combinations of Pomona, Azusa, and Pasadena oxidant and regressed these against DOLA and Whittier precursors. On physical grounds, it is reasonable to expect that the oxidants of different receptor sites will correlate best at different wind directions. For example, southerly winds will tend to transport DOLA and Whittier hydrocarbons northward into Pasadena, while westerlies will tend to push these precursors eastward toward Pomona. For the basic equation: OX* =(a)PASOX + (b)AZUOX + (c)POMOX, we defined seven different sets of weighting coefficients a, b, c, all functions of the wind direction at DOLA. For a given wind direction, these weighting factors are made to add up to unity, i.e., 1.0 = a+b+c. The seven sets of weightings used and the corresponding correlation coefficients between OX* and the DOLA and Whittier precursors are listed in Table 4.4. The best of these weighting schemes, i.e., the one giving the highest correlations of OX* against all precursors, is the seventh one, which omits Pomona entirely and assigns OX* = Pasadena oxidant for southerly winds and OX* = Azusa oxidant for westerly winds.

The decision to use only Azusa and Pasadena oxidant in defining OX* is supported by a brief test in which the coefficients of OX* were made functions of wind <u>speed</u> instead of wind direction. For this test, OX* was set equal to Pomona oxidant for wind speeds over a given threshold, and set equal to the average of the Azusa and Pasadena oxidants for slower winds. Table 4.5 shows that the higher the threshold wind value, the stronger the correlation coefficients, or, in other words, the less use of Pomona oxidant, the better.

The next test was to regress the Pasadena, Azusa, and Pomona oxidants against various linear combinations of the DOLA and Whittier precursors. The basic linear combination equations were: HC* = d·DOLA HC + e·WHT HC and NO_x* = d·DOLA NO_x + e·WHT NO_x, where coefficients d and e depend on wind direction, and for any given wind direciton, d+e=1.0. Table 4.6 lists the various sets of d and e used and the resulting oxidant-precursor correlations. Note that the best coefficient set found is the third one listed, although the differences among the correlation coefficients are small due to the similarity of their definitions.

A final series of regressions was performed, using variations of the best OX*, HC* and NO_x* of the preceding regressions. Table 4.7 presents the definitions of the various linear combination functions and the correlations

Table 4.4. Correlations Between OX^* and Precursors for Various Definitions of OX^*

	Coefficients a,b,c of OX^*						
DOLA WD	CASE 1	2	3	4	5	6	7
S	1,0,0	1,0,0	1,0,0	1,0,0	1,0,0	1,0,0	1,0,0
SSW	0,1,0	.5,.5,0	.5,.5,0	1,0,0	1,0,0	1,0,0	1,0,0
SW	0,1,0	0,1,0	.3,.3,.3	.5,.5,0	.5,.5,0	0,1,0	1,0,0
WSW	0,0,1	0,.5,.5	0,.5,.5	0,1,0	.3,.3,.3	0,1,0	0,1,0
W	0,0,1	0,0,1	0,0,1	0,.5,.5	0,.5,.5	0,0,1	0,1,0

	Correlation Coefficients						
Precursor							
DOLA NO_X	.28	.29	.32	.36	.33	.35	.45
WHT NO_X	.25	.27	.28	.31	.28	.30	.38
DOLA HC	.38	.42	.43	.48	.45	.46	.52
WHT HC	.33	.33	.34	.37	.35	.36	.45

$OX^* = a \cdot$ PASADENA OX + b $\cdot$ AZUSA OX + c $\cdot$ POMONA OX. Entry format: a,b,c

Number of data points in regression ≈ 400

(Significant correlations are those exceeding $2/\sqrt{400} \approx .1$)

Table 4.5 Correlations Between OX* and Precursors by DOLA Wind Speed

	Threshold Wind Speed* 4.5	5	6
DOLA NO_x	.30	.30	.31
WHIT NO_x	.26	.26	.27
DOLA HC	.39	.40	.41
WHT HC	.35	.34	.35

OX = Pomona OX for Average Wind Speed > Threshold

OX* = (Azusa OX + Pasadena OX)/2 for Wind Speed $\leq$ Threshold

Table 4.6 Correlation Between Oxidant and Linear Combinations of Precursor

DOLA WIND	Precursor Weighting Coefficients* CASE 1	CASE 2	CASE 3
S	0,1	.5,.5	0,1
SSW	.5,.5	.5,.5	.5,.5
SW	.5,.5	.5,.5	.5,.5
WSW	.5,.5	.5,.5	1,0
W	1,0	.5,.5	1,0

Correlation Coefficients

	1 HC	1 NO_x	2 HC	2 NO_x	3 HC	3 NO_x
Pasadena OX	.45	.35	.45	.36	.49	.39
Azusa OX	.44	.32	.44	.34	.47	.34
Pomona OX	.37	.24	.38	.26	.38	.26

Format: (d,e) where HC = d·(DOLA HC) + e·(Whittier HC)

e.g., (0,1) means that HC* = (Whittier HC)

(.5,.5) means that HC* = (DOLA HC + Whittier HC)/2

Table 4.7a. OX^* - HC^* and NO_X^* Definition Coefficients

DOLA WD	OX^*-1	OX^*-2	OX^*-3	OX^*-4	HC^*-1	HC^*-2	NO_X^*-1	NO_X^*-2
8	1,0	1,0	1,0	1,0	0,1	A	0,1	A
9	1,0	1,0	1,0	1,0	.5,.5	B	.5,.5	B
10	.5,.5	1,0	1,0	C	.5,.5	B	.5,.5	B
11	.5,.5	.5,.5	.5,.5	C	1,0	1,0	1,0	1,0
12	0,1	.5,.5	0,1	D	1,0	1,0	1,0	1,0

A: (0,1) if Long Beach wind SE through W; otherwise (.5,.5)

B: (.5,.5) if Long Beach wind SE through W; otherwise (1,0)

C: (1,0) if Ontario wind N through SE: otherwise (.5,.5)

D: (1,0) if Ontario wind N through SE; otherwise (0,1)

Format: (a,b) where a = Pasadena coefficient, b = Azusa coefficient for oxidants; a = DOLA, b = Whittier for precursors

Table 4.7b. Correlations Among OX^* and HC^* and NO_X^*

	OX^*-1	OX^*-2	OX^*-3	OX^*-4
HC^*-1	.48	.48	.48	.48
HC^*-2	.55	.56	.56	.55
NO_X^*-1	.39	.40	.39	.39
NO_X^*-2	.42	.43	.43	.42

among them. The best results were obtained using the second or third set of OX* and the second set of HC* and NO_x*. Not surprisingly, these oxidants and precursors are dominated by Pasadena and DOLA, respectively. These are the oxidant and precursor values, respectively, that will be used in the algorithm development from Scenario III. The oxidant-hydrocarbon correlation of .56 and the oxidant-NO_x correlation of .43 are reasonably encouraging and indicate that it should be feasible to generate a reasonable oxidant/precursor model from the data. Although these choices of oxidant and precursors strongly resemble those of Scenario II in their domination by Pasadena OX and DOLA HC and NO_x, they are different enough from Scenario II to be worth further study.

One final note: as the precursor transport distance increases from one Scenario to the next, the oxidant-precursor correlations gradually soften, due to interference from other source regions and to complexity introduced by surface dispersion and transport by elevated winds. These weakening coefficients indicate that the oxidant-precursor models will probably be most successful for the shorter transport distances.

5.0 "SCENARIO IV": LATE AFTERNOON OXIDANT AFTER LONG-RANGE TRANSPORT

This study attempts to relate late afternoon (2 to 6 PM) oxidant levels in the San Bernardino-Riverside area to morning hydrocarbon and NO_x concentrations at Whittier, Anaheim, and Lennox. As in Scenario III, a shortage of hydrocarbon data prevented the inclusion of precursor data from additional sites near the chosen source area. Because of the considerable separation of sources and receptors and because of the possible interference effects of precursors from other areas, we anticipate much weaker oxidant-precursor correlations in this scenario than in the previous ones.

5.1 COMPILATION OF DATA BASE FOR "SCENARIO IV"

The air quality portion of the Scenario IV data base comprises the following: 1) the 6-9 AM 3-hour average NO_x concentrations at Lennox, Whittier, and Anaheim; 2) the 6-9 AM 3-hour average hydrocarbon levels at these sites; 3) the four 1-hour oxidant averages between 2 and 6 PM at Upland, San Bernardino, Redlands, and Rubidoux; and 4) the 2-5 and 3-6 PM 3-hour average oxidant concentrations derived from the four 1-hour averages at these sites.

These air quality data are supplemented by the following meteorological data: 1) the Ontario and Long Beach hourly wind speed and direction data for 9 AM to 4 PM; 2) midday vector average wind speed and direction at these sites; 3) the midday average temperatures at Ontario, Long Beach, and DOLA; 4) the daily maximum temperature at Mt. Wilson; 5) the midday average solar radiation at DOLA; 6) the computed daily maximum mixing height at DOLA; 7) the inversion strength and height data from airport soundings (LAX and El Monte); and 8) the speed and direction of the mean wind of the Los Angeles Basin at the elevation corresponding to a pressure of 850 mb. San Bernardino surface wind data would have been desirable, but are available only in handwritten form and would therefore have to be key-punched for inclusion in the data base.

5.2 PRELIMINARY ANALYSIS OF OXIDANT-PRECURSOR RELATIONSHIP

The first statistical test performed was a series of regressions between the 3-hour oxidant averages of the four receptor stations and the precursor concentrations at the three source sites. Table 5.1 lists the weak correlations obtained. Note that less than half of the correlations are statistically significant at the 95% confidence level, or, in other words, in most cases a given oxidant value appears not to be significantly related to the concentration of a given precursor. It is also interesting to note that all of the significant correlation coefficients are negative, indicating inverse relationships between oxidants and precursors. As will be discussed later in Section 5.3, this is not physically unreasonable. In the absence of distance-related meteorological biases or oxidant depletion effects, however, one would anticipate significant (or zero) correlations (not significant negative correlations) between widely-spaced sources and receptors.

As in the earlier scenarios, we sorted the data base by surface wind direction to try to improve the correlation coefficients. When the data base is restricted to days having southwesterly or westerly surface winds, the

Table 5.1 Oxidant-Precursor Correlations Without Meteorological Restrictions

	UPLAND		SAN BERNARDINO		REDLANDS		RUBIDOUX	
	OX31	OX32	OX31	OX32	OX31	OX32	OX31	OX32
Len. NO_x	-.10	-.07	-.16	-.15	-.27	-.24	-.21	-.16
Wht. NO_x	-.01	-.00	-.14	-.13	-.18	-.16	-.08	-.04
Anh. NO_x	.04	.05	-.08	-.06	-.15	-.13	-.05	-.01
Len. HC	.04	.08	-.14	-.11	-.29	-.25	-.12	-.06
Wht. HC	.04	.05	-.09	-.08	-.12	-.09	-.05	-.01
Anh. HC	.11	.11	-.11	-.09	-.07	-.05	-.08	-.04
Number of Cases	300		450		250		350	

Table 5.2 Oxidant-Precursor Correlations With Surface Wind Restrictions

	UPLAND		SAN BERNARDINO		REDLANDS		RUBIDOUX	
	OX31	OX32	OX31	OX32	OX31	OX32	OX31	OX32
Len. NO_x	-.03	-.03	-.07	-.06	-.20	-.17	-.10	-.05
Wht. NO_x	.06	.06	-.07	-.05	-.11	-.08	.05	.08
Anh. NO_x	.09	.08	-.02	-.00	-.11	-.09	.04	.07
Len. HC	.15	.15	-.04	-.01	-.22	-.17	.02	.07
Wht. HC	.10	.10	-.04	-.02	-.07	-.03	.06	.09
Anh. HC	.16	.15	-.07	-.04	-.04	-.01	-.00	.03
Number of Cases	250		400		200		300	

Not statistically significant at the 95% confidence level.

[Statistical significance at 95% level requires $R \geq 2/\sqrt{N}$ where N = number of cases. Statistical significance at 99% level would require $R \geq 2.6/\sqrt{N}$.]

correlations in Table 5.2 are obtained. The wind restriction used is: Long Beach wind in the southwest quadrant, from south to west, inclusive, and Ontario wind from SSW to WNW, inclusive. As Table 5.2 illustrates, nearly all correlations rise in value (i.e., negative correlations become less negative) when the wind sort is applied. Few significant positive or negative correlations emerge from this portion of the analysis.

Because of the separation of sources and receptors in this scenario, the possibility of elevated transport of precursors or oxidant must be considered. Also, vertical diffusion, particularly if it is different in the source and receptor sites, may be significant in this scenario. Since the afternoon maximum mixing height is related to both the transport of pollutants aloft and the vertical dispersion of pollutants, we decided to stratify the data by mixing height to try to improve the oxidant-precursor correlations. From the mixing height histogram, the 25th, 50th, and 75th percentile mixing heights were determined. (See Figure 5.1) Regressions were then run on those data corresponding to days within each of the four mixing height quartiles. Table 5.3 shows that the mixing height stratification improved the oxidant-precursor correlations at Upland and Rubidoux, although it did not greatly help the San Bernardino and Redlands results. Only at the lower mixing heights, and between Rubidoux and Upland oxidants and Lennox hydrocarbons, do we consistently obtain significant correlations. At the greatest mixing heights there are no statistically significant oxidant-precursor correlations at any of the sites.

Since the Rubidoux site had the greatest number of significant oxidant-precursor correlations, it was selected for further study. Two final series

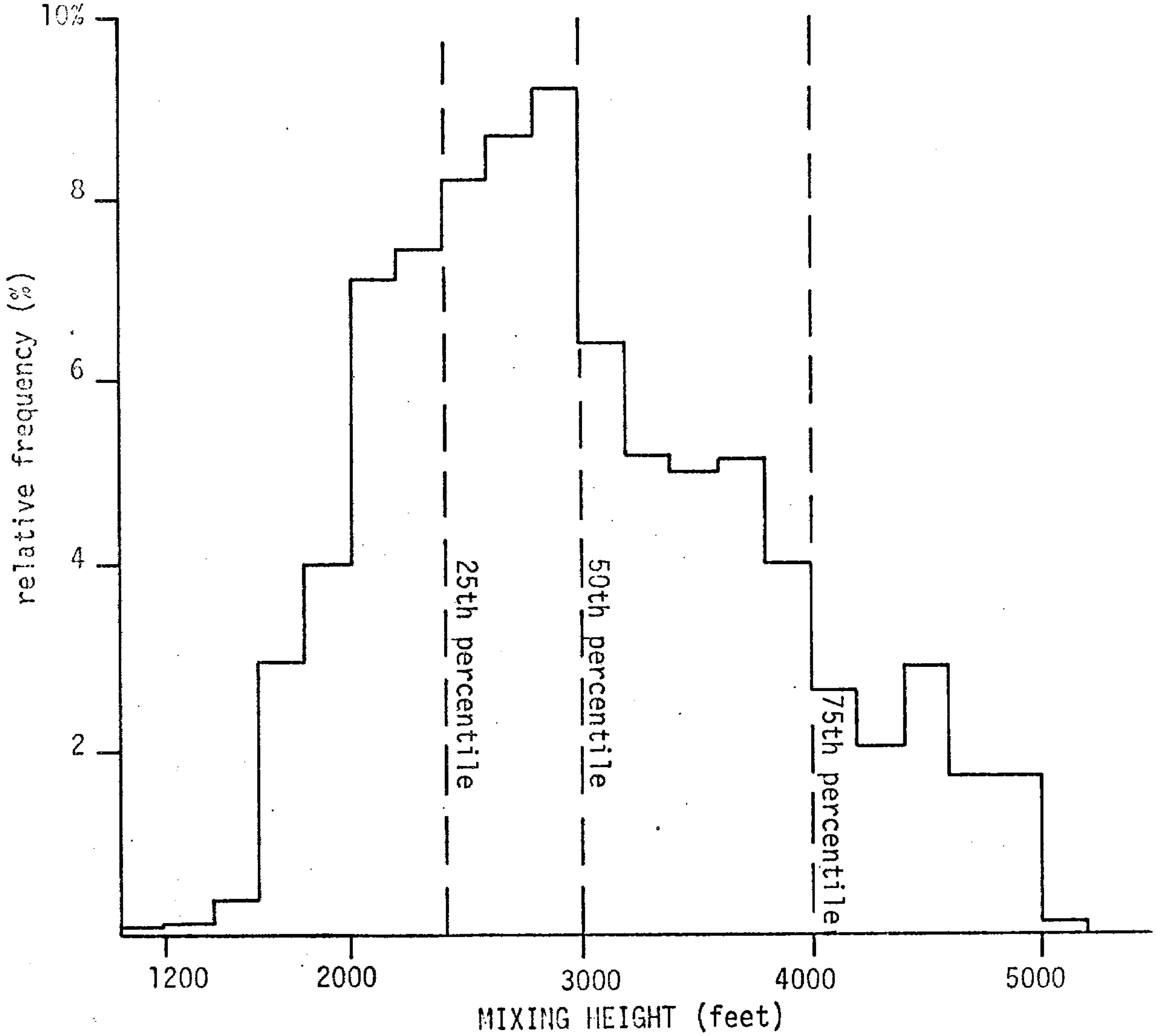

Figure 5.1. Histogram of DOLA Daily Maximum Mixing Heights

Table 5.3 Oxidant-Precursor Correlations with Surface Wind Mixing Height Stratifications

N*	Upland OX31	Upland OX32	San Bernardino OX31	San Bernardino OX32	Redlands OX31	Redlands OX32	Rubidoux OX31	Rubidoux OX32
Afternoon mix ht. ≤ 2450'								
	64		75		40		66	
Len. NO_x	.22	.17	-.05	-.00	-.11	-.04	.21	.21
Wht. NO_x	.07	.06	-.26	-.19	-.18	-.25	.24	.28
Anh. NO_x	.18	.20	-.14	-.07	-.13	-.20	.33	.39
Len. HC	.38	.35	-.05	.03	-.17	-.11	.38	.44
Wht. HC	.01	.05	-.27	-.24	-.32	-.39	.09	.17
Anh. HC	.04	.10	-.22	-.13	-.13	-.09	.13	.22
2450' < MH < 3050'								
	79		115		55		84	
Len. NO_x	.14	.11	.21	.18	.09	.10	.17	.15
Wht. NO_x	.03	.04	.05	.08	-.09	.02	.10	.09
Anh. NO_x	.08	.01	.10	.13	-.12	-.04	.14	.13
Len. HC	.28	.26	.11	.16	-.15	-.06	.21	.21
Wht. HC	-.02	-.03	-.17	-.13	-.19	-.12	.02	.02
Anh. HC	.04	.02	-.16	-.09	-.17	-.10	-.02	.02
3050' < MH < 4050'								
	74		106		48		85	
Len. NO_x	-.02	-.00	.10	.06	-.18	-.13	.09	.14
Wht. NO_x	.00	.02	.10	.08	.02	.07	.13	.15
Anh. NO_x	.02	.03	.21	.18	.02	.07	.14	.14
Len. HC	.13	.16	.16	.15	-.17	-.13	.28	.31
Wht. HC	.01	.05	.21	.19	.03	.10	.15	.18
Anh. HC	.02	.04	.08	.05	.13	.12	.09	.09
4050' < MH < 5150'								
	18		45		30		26	
Len. NO_x	.14	.10	.08	.20	-.21	.16	.20	.23
Wht. NO_x	.09	.08	-.08	.02	-.10	.06	.09	.08
Anh. NO_x	.16	.17	.01	.09	-.06	.09	.14	.15
Len. HC	.25	.20	.10	.21	-.15	-.00	.26	.29
Wht. HC	.05	.03	-.07	.05	-.10	.06	.22	.19
Anh. HC	.07	.07	-.15	-.03	-.13	-.00	-.11	-.15

*Number of Cases

of regressions were made, one with stratification by winds aloft and the other using independent variables consisting of linear combinations of the precursor levels of the source areas. Table 5.4 presents the results of stratifying the data base by both winds aloft and mixing height data. A few significant correlations are obtained at the lower mixing heights, but no source site shows consistently strong correlations.

Table 5.4 Rubidoux Oxidant-Precursor Correlations-
Stratification by Winds Aloft and Maximum Mixing Height

	≤ 2450'		2450'-3050'		3050'-4050'	
	OX31	OX32	OX31	OX32	OX31	OX32
Number of Cases	100		82		84	
Len. NO_x	.05	-.02	.30	.30	-.16	-.13
Whit. NO_x	.26	.30	.18	.19	-.02	-.07
Anh. NO_x	.38	.41	.13	.16	-.04	-.10
Len. HC	.24	.20	.31	.30	+.05	-.00
Whit. HC	.24	.32	.15	.12	-.11	-.13
Anh. HC	.13	.18	.10	.16	-.17	-.19

The final regressions were made between the second three-hour Rubidoux oxidant and various combinations of hydrocarbon and NO_x concentrations of the three source sites. The data base was restricted to days having southwesterly surface winds and Long Beach and Ontario (as earlier) and having mixing heights of less than 2450 feet (lowest quartile). Table 5.5 defines the coefficients of the precursor linear combinations and presents the oxidant-precursor correlations obtained. The choices of precursor coefficients were made by examining the geographic orientations of the sources and receptors. As in the previous scenarios, we made the precursor coefficients functions of wind direction to account for differences in pollutant transport. Table 5.5 lists the three sets of precursor coefficients used in this study. Note that one of the sets is based on a sort by Long Beach surface wind direction, another by Ontario, and the third by both.

In terms of hydrocarbons, the best linear combination is that which makes use of both the Long Beach and the Ontario wind directions. (See Table 5.5b) The correlation between Rubidoux oxidant and this linear combination of precursors is the best obtained in this study, indicating that model development, if pursued, should begin with these values of oxidant and precursors.

5.3 THE IMPACT OF SOURCE-RECEPTOR SITE SEPARATION ON OXIDANT-PRECURSOR CORRELATIONS

In performing the analyses of the five scenarios of this study, we determined that, not surprisingly, the oxidant-hydrocarbon correlation generally weakens as the source-receptor separation increases. However, the correlation does not simply weaken toward insignificance as distance increases, but it becomes progressively more negative, so that it is _significantly negative_ at large separations (e.g., 100 miles). (See Figure 5.2). This indicates that there may be certain meteorological

Table 5.5a Defining Coefficients for Linear Combinations of Precursors

Set 1 - Sort by Both Long Beach and Ontario Wind Directions

Ontario Wind Direction:	Long Beach Wind Direction: S	SSW	SW	WSW	W
SSW	0,.5,.5	0,.5,.5	.3,.3,.3	.3,.3,.3	.3,.3,.3*
SW	0,.5,.5	0,.5,.5	.3,.3,.3	.3,.3,.3	.3,.3,.3
WSW	0,.5,.5	0,.5,.5	.3,.3,.3	.3,.3,.3	.3,.3,.3
W	0,1,0	0,1,0	.3,.3,.3	.3,.3,.3	.3,.3,.3
WNW	0,1,0	0,1,0	0,1,0	0,1,0	0,1,0

Set 2 - Long Beach Wind Direction Sort

S	SSW	SW	WSW	W
0,.5,.5	0,.5,.5	.3,.3,.3	.3,.3,.3	.3,.3,.3

Set 3 - Ontario Wind Direction Sort

SSW	SW	WSW	W	WNW
.3,.3,.3	.3,.3,.3	.3,.3,.3	.3,.3,.3	0,1,0

Table 5.5b Oxidant-Precursor Correlations**

	Precursor: Lennox	Whittier	Anaheim	Set 1	Set 2	Set 3
HC	.29	.29	.20	.35	.34	.32
NO_x	.09	.35	.33	.34	.38	.30

Coefficients of Lennox, Whittier, and Anaheim, respectively. (.3,.3,.3) means: HC = Lennox (Len HC + Wht HC + Anh HC)/3
(0,1,0) means: HC* = Wht HC; etc.

**Mixing Height < 2450' 100 + cases
Surface Winds Southwesterly

Not significant at 95% confidence level.

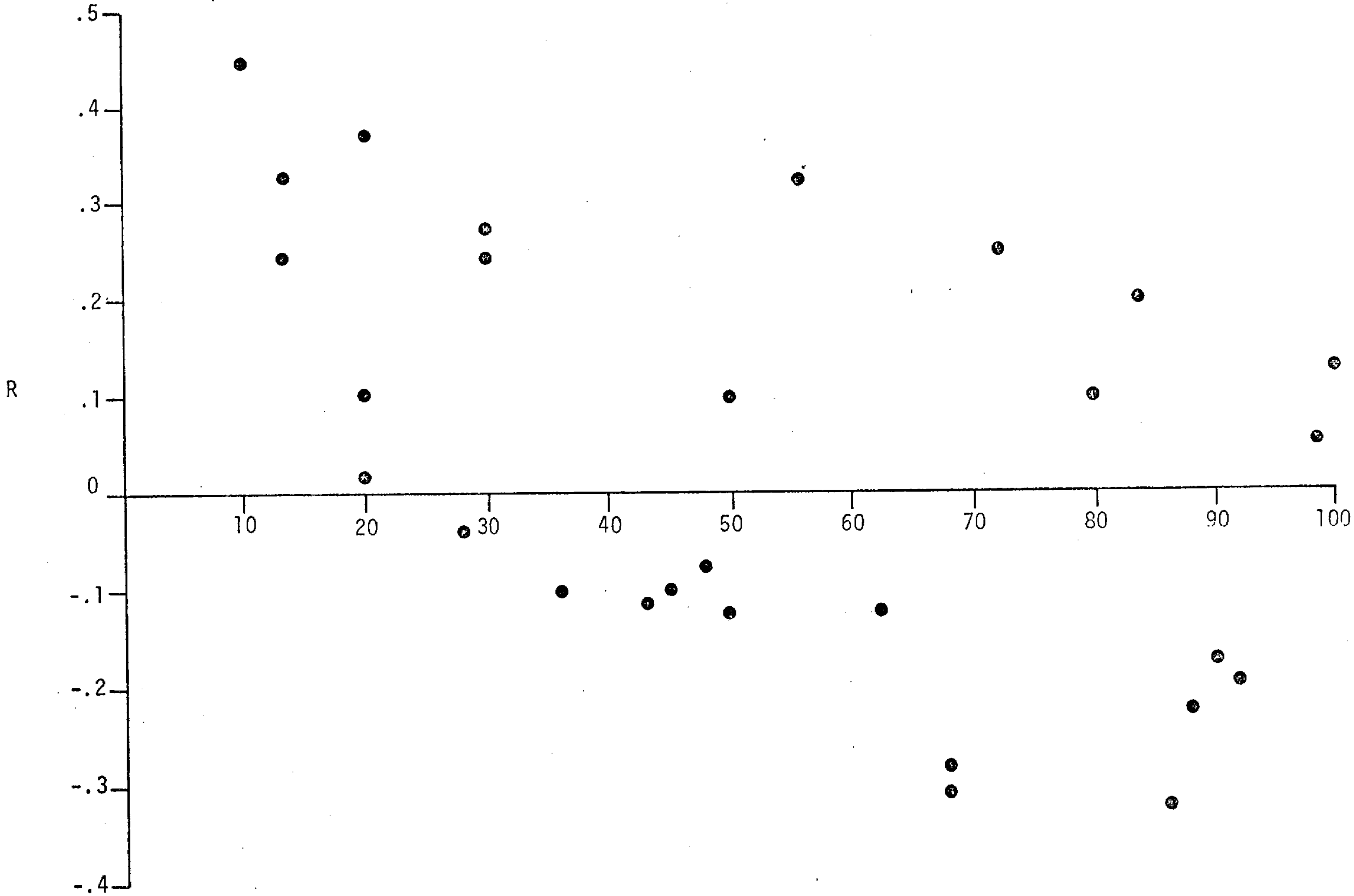

Figure 5.2 Relationship of OX-HC Correlation Coefficient to Source-Receptor Separation

conditions which produce high afternoon oxidant concentrations with low morning hydrocarbon levels, or vice-versa. For example, contrast the effects of a weak but low morning inversion with those of a stronger but higher morning inversion. If all other factors are equal, the former will give rise to higher morning hydrocarbons than the latter, due to its more reduced vertical dispersion. However, it will contribute to lower afternoon oxidants by burning off during the day, permitting increased vertical dilution. The stronger inversion will last later into the day, maintaining a dilution lid. If both of these conditions occur frequently, they will contribute to a negative correlation between oxidants and hydrocarbons, which can overshadow any weak positive correlation that might be present. At large source-reception separation, the causal oxidant-hydrocarbon link will weaken, due to increased dilution and interference from other areas.

There is at least one other reasonable explanation for the significant negative oxidant-precursor correlations obtained at the higher source-receptor separations. When morning hydrocarbon concentrations are low, the photochemical oxidant formation reactions will proceed more slowly than when concentrations are higher. (This follows from the laws of chemical kinetics, which relate reaction rates to the concentrations of reactants and products.) The result is that oxidant may still be forming from its precursors and reaching its peak level as an air mass reaches the receptor site. In contrast, higher hydrocarbon and NO_x concentrations will cause more rapid oxidant formation.

In this case, the oxidant formation reactions will go to completion before the air mass reaches the receptor site, with the result that the highest oxidant may be reached at a site between the source and receptor. As the air mass continues to move toward the ultimate receptor site, the oxidant which has formed begins to dissociate or to be scavenged by local NO or absorbed by surfaces.* Because of this dissociation, the oxidant concentration at the receptor site may actually be lower than that caused by lower precursor concentrations. This oxidant formation/depletion mechanism, sketched in Figure 5.3, explains why one should obtain a positive oxidant-precursor correlation at receptors near the source (receptor 1 in the figure), negative correlations at distant receptors (receptor 2), and zero (insignificant) correlations at certain intermediate sites (receptor 3). The oxidant-hydrocarbon correlation, starting at a low positive level when the receptor is at the source site (e.g. Scenario I), should become increasingly positive, reaching a maximum at low-to-moderate source-receptor separation (Scenario II). According to the figure, it should then decline to insignificance (Scenario IV), finally becoming negative at the higher source-receptor separat-ons (Scenario V). This is entirely consistent with the results of the Scenario I through V regressions

*The absorption of O_3 by surfaces causes indoor ozone levels to be lower than those outdoors, leading to the "indoor-outdoor" effect.

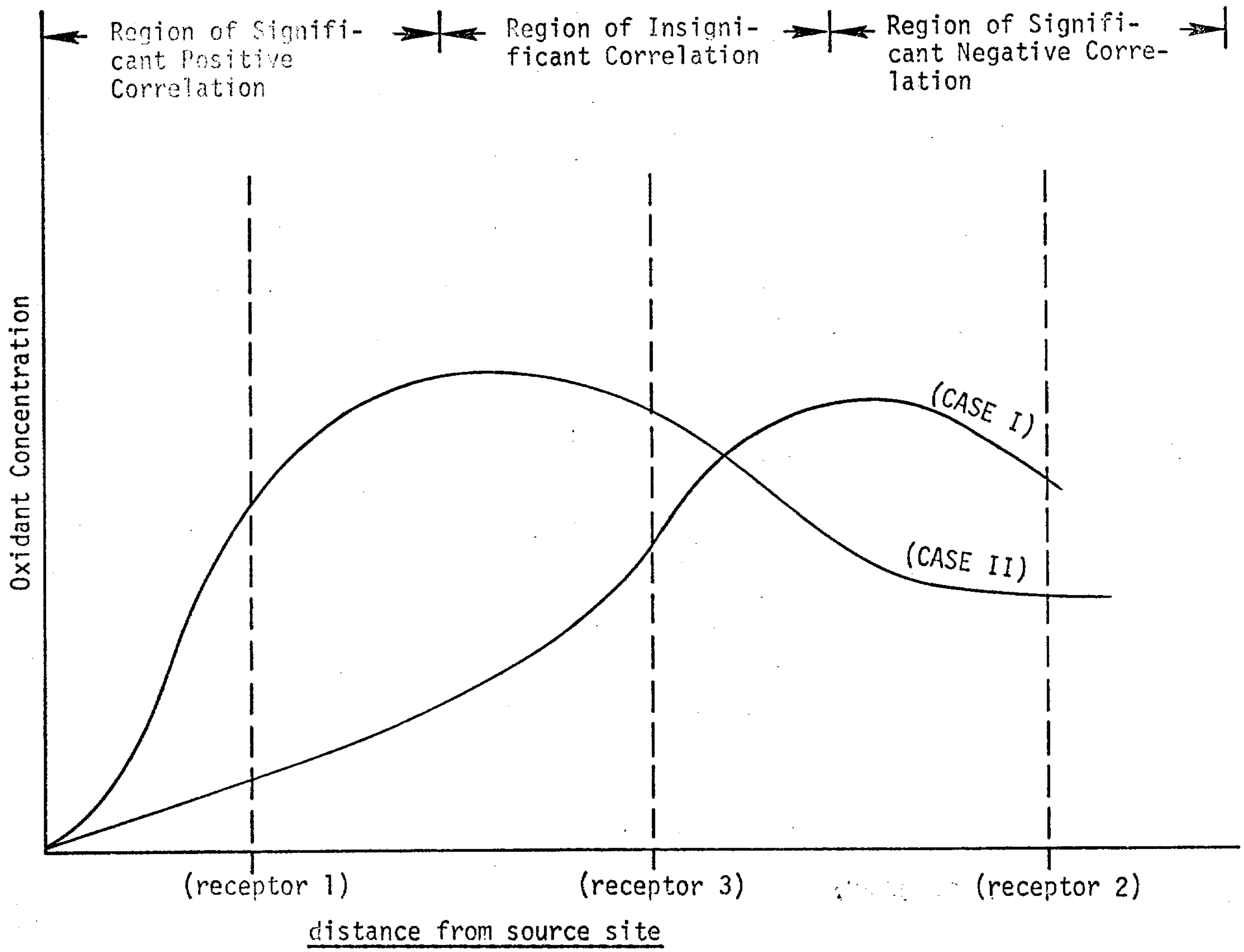

Figure 5.3 Oxidant Concentration as a Function of Distance from Source Site for Low (CASE I) and High (CASE II) Precursor Concentrations

and explains why one will be unable to obtain significant positive oxidant-hydrocarbon correlations for widely spaced sources and receptors, irrespective of the level of meteorological data stratification attempted.

An implication of this simple model is that the short-range scenarios, with their significant positive oxidant-hydrocarbon correlations, will be easier to model than the longer range ones. Another implication, however, is that the low and the negative oxidant-hydrocarbon correlations of the long-range scenarios are not necessarily indicative of poor data quality or high interference, but may be due to physical and chemical atmospheric processes. If this is the case, then there is some chance for success in modeling the longer range scenarios.

6.0 "SCENARIO V": EARLY EVENING OXIDANT FOLLOWING VERY LONG RANGE TRANSPORT

This scenario examines the impact of morning hydrocarbon and NO_x levels in the coastal and central SCAB on early evening oxidants in Banning and Palm Springs. Because of the extended transport distances (up to 105 miles) involved, this study will utilize 4-8 PM oxidant readings at the receptor sites and 6-9 AM precursor levels at the source sites. The seven-to-fourteen hour time interval between the oxidant and precursor readings is sufficient to permit transport from sources to receptors by winds of at least 6 miles per hour, which are fairly common in the afternoons in the SCAB. Because of the dilution and horizontal dispersion that would accompany this extended range transport of pollutants, we have chosen a broad source area. With a narrower source area, one would anticipate greater interference caused by precursor pollutants from other areas.

6.1 COMPILATION OF DATA BASE FOR SCENARIO V

The data base for this scenario includes the following air quality data: 1) the 4-5, 5-6, 6-7, and 7-8 PM one-hour oxidant readings at Banning and at Palm Springs; 2) the 4-7 and 5-8 PM 3-hour oxidant averages derived from these; 3) the 6-9 AM hydrocarbon concentrations at Lennox, DOLA, Anaheim, Whittier, Pasadena, Azusa, Pomona, and San Bernardino; and 4) the 6-9 AM NO_x levels at these 8 sites.

These air quality data were complemented by the following meteorological data: 1) 10 AM to 4 PM wind speed and direction at Ontario and DOLA; 2) daily maximum temperature at Ontario and DOLA; 3) midday average solar radiation at DOLA; 4) daily maximum mixing height at DOLA; 5) daily maximum temperature at Mt. Wilson; 6) morning inversion base height at DOLA; and 7) average SCAB wind speed and direction at the 850 mb height.

6.2 PRELIMINARY ANALYSIS OF THE OXIDANT-PRECURSOR RELATIONSHIP

The first statistical test of this data base was to compute the correlation coefficients between 3-hour average oxidants at the two receptor sites and 3-hour average precursor levels at the eight source sites. Table 6.1, which lists the results, shows that some 50% of the correlations obtained are insignificant and that hydrocarbons tend to correlate more strongly with oxidant than do NO_x.

Significant negative correlations dominate the Anaheim, Lennox, and Whittier coefficients, while DOLA, Pomona, and Azusa show significant positive correlations. San Bernardino correlations are mixed, with positive hydrocarbons and negative NO_x, while Pasadena correlations are all essentially zero (insignificant). Figure 6.1, a map of the source and receptor sites and major (2500-5000 ft) local mountain ranges, summarizes the OX-HC and OX-NO_x correlations corresponding to each source site. The trend toward more negative correlations with increasing source-receptor separation is readily apparent.

On the basis of these regression coefficients, we decided to restrict the Banning study to the OX 5-8 value. Next, we restricted the data base to days having southwesterly wind (directions SSW through NW) at DOLA and westerly (directions SW through NW) at Ontario. As Table 6.2 shows, this wind direction restriction tends to weaken the stronger positive and negative correlation coefficients, but has no dramatic impacts overall.

Table 6.1 Oxidant-Precursor Correlations Without Meteorological Restrictions

No. of cases = 123 $2/\sqrt{N} > .18$

	POM	DOLA	S BERN	LENX	WHT	AZUSA	ANH	PAS	
Banning	.09	-.18	-.09	-.27	-.26	.31	-.18	.08	NO_x
OX 4-7	.29	-.25	.23	-.16	-.24	.17	-.32	.06	HC
Banning	.10	-.15	-.10	-.26	-.22	.36	-.14	.12	NO_x
OX 5-8	.31	-.19	.25	-.14	-.21	.19	-.30	.09	HC
Palm Spr	.09	-.11	-.14	-.22	-.21	.24	-.20	.04	NO_x
OX 4-7	.19	-.22	.09	-.13	-.22	.15	-.33	.05	HC
Palm Spr	.05	-.13	-.14	-.24	-.20	.23	-.19	.00	NO_x
OX 5-8	.18	-.20	.07	-.14	-.20	.15	-.30	.04	HC

Table 6.2 Oxidant-Precursor Correlations with DOLA and Ontario Wind Direction Restrictions

No. of Cases = 186 $2/\sqrt{N} > .14$

Banning	.15	-.03	-.03	-.10	-.10	.24	.00	.18	NO_x
OX 5-8	.26	-.07	.23	.03	-.10	.13	-.19	.18	HC

N = 101 $2/\sqrt{N} = .2$

Palm Spr	.11	-.02	-.12	-.19	-.15	.23	-.14	.07	NO_x
OX 4-7	.24	-.21	.06	-.09	-.16	.15	-.31	.04	HC
Palm Spr	.07	-.04	-.15	-.21	-.13	.22	-.13	.04	NO_x
OX 5-8	.24	-.19	.05	-.09	-.13	.14	-.26	.03	HC

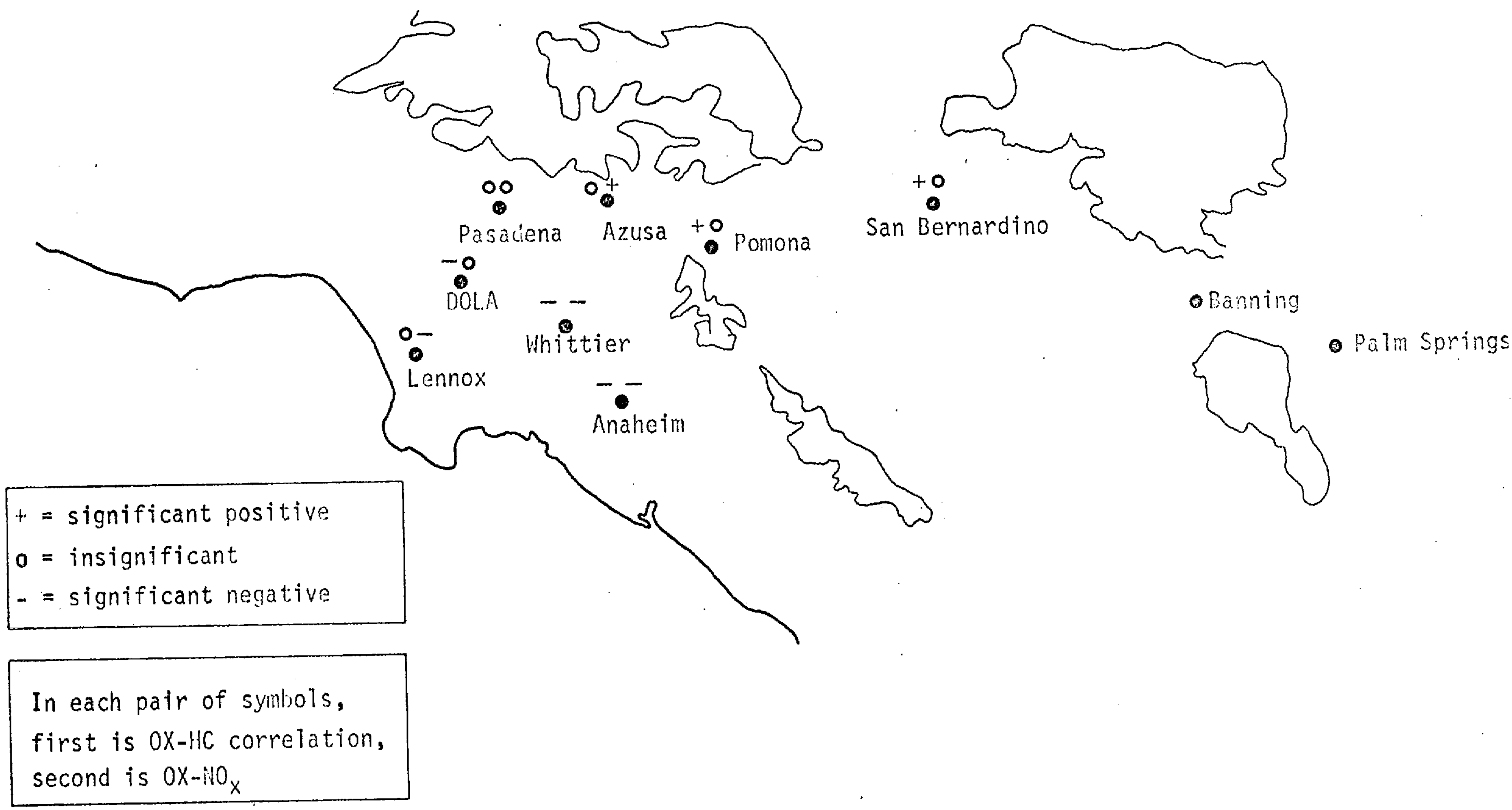

Figure 6.1. Oxidant-Precursor Correlations at Scenario 5 Source Sites

One reason for the weak effect of this wind direction sort is that it eliminated only 20% of the days in the data base. The small size of the data base prevented the application of a more restrictive wind direction sort.

The next set of regressions involved restricting the DOLA and Ontario midday average wind speeds to: 1) greater than 3 mph; 2) greater than 4 mph; and 3) greater than 5 mph. The mixed, subtle effects of these sorts are the subject of Table 6.3. Note that the more restrictive wind speed sorts actually decrease the number of significant OX-precursor correlations.

Stratification of the data base by daily maximum mixing height at DOLA (using the estimate from the SCAQMD's "weather summary" tape) was similarly nonproductive. (Table 6.4) Somewhat more successful was a stratification of the data base by morning inversion base height at LAX (Table 6.5). Positive oxidant-NO_X correlations for Azusa, negative oxidant-precursor correlations for Anaheim, negative oxidant-hydrocarbon correlations for DOLA, and little else are obtained.

Table 6.6 summarizes the effects of these data base stratifications on the oxidant-hydrocarbon correlations. San Bernardino and Pomona, consistently exhibit significant positive correlations, which are not dramatically affected by the various meteorological stratifications. With certain meteorological stratifications, the Azusa and Pasadena sites exhibit weak positive oxidant-hydrocarbon correlations with the Banning receptor site, while the hydrocarbons of the Lennox site consistently correlate poorly with the various receptor oxidants. The Whittier and DOLA sites exhibit some modestly significant, consistently negative correlations, while the Anaheim correlations

Table 6.3 Oxidant-Precursor Correlations with DOLA and Ontario Wind Speed Restrictions

	POM	DOLA	S BERN	LENX	WHT	AZUSA	ANH	PAS	
			N = 205	$(2/\sqrt{N} = .14)$			WS > 3 mph		
Banning	.15	-.12	-.01	-.16	-.14	.26	-.03	.16	NO_x
OX 5-8	.24	-.09	.27	-.07	-.17	.18	-.22	.18	HC
			N = 111	$(2/\sqrt{N} = .19)$					
Palm Spr	.12	-.11	-.10	-.19	-.20	.22	-.18	.08	NO_x
OX 4-7	.20	-.23	.09	-.12	-.23	.16	-.34	.06	HC
Palm Spr	.09	-.11	-.11	-.20	-.18	.21	-.17	.05	NO_x
OX 5-8	.20	-.21	.09	-.12	-.20	.15	-.29	.07	HC
			N = 191	$(2/\sqrt{N} = .14)$			WS > 4 mph		
Banning	.16	-.09	.02	-.11	-.12	.25	-.03	.16	NO_x
OX 5-8	.25	-.09	.26	-.03	-.13	.15	-.22	.17	HC
			N = 105	$(2/\sqrt{N} = .2)$					
Palm Spr	.12	-.11	-.07	-.17	-.19	.22	-.18	.05	NO_x
OX 4-7	.19	-.23	.10	-.09	-.22	.15	-.35	.05	HC
Palm Spr	.08	-.12	-.09	-.13	-.17	.20	-.17	.02	NO_x
OX 5-8	.13	-.21	.10	-.09	-.18	.14	-.30	.05	HC
			N = 179	$(2/\sqrt{N} = .15)$			WS > 5 mph		
Banning	.15	-.10	.03	-.10	-.12	.23	-.03	.19	NO_x
OX 5-8	.26	-.09	.28	-.01	-.11	.14	-.22	.18	HC
			N = 99	$(2/\sqrt{N} = .2)$					
Palm Spr	.13	-.12	-.04	-.15	-.18	.21	-.15	.09	NO_x
OX 4-7	.21	-.22	.10	-.07	-.18	.15	-.32	.05	HC
Palm Spr	.10	-.13	-.07	-.16	-.16	.20	-.13	.06	NO_x
OX 5-8	.20	-.19	.11	-.07	-.14	.14	-.27	.05	HC

Table 6.4 Oxidant-Precursor Correlations with Daily Maximum Mixing Height Stratification

	POM	DOLA	S BERN	LENX	WHT	AZUSA	ANH	PAS	
				MH < 2950'	N = 98-B;	N = 52-PS			
Banning	.06	-.20	-.04	-.07	-.19	.00	-.07	.09	NO_x
OX 5-8	.07	-.24	.05	.04	-.26	-.17	-.39	.02	HC
Palm Spr	.22	.00	-.04	-.01	-.12	.15	-.12	.17	NO_x
OX 4-7	.21	-.26	-.03	-.05	-.18	-.03	-.35	-.07	HC
Palm Spr	.16	-.01	-.03	-.01	-.11	.10	-.10	.10	NO_x
OX 5-8	.19	-.24	-.05	-.03	-.15	-.06	-.29	-.10	HC
				MH > 2950'	N = 99-B	N = 53-PS			
Banning	.07	-.10	-.06	-.04	-.10	.20	-.02	.15	NO_x
OX 5-8	.25	-.07	.20	.10	-.12	.16	-.21	.26	HC
Palm Spr	-.01	-.18	-.22	-.10	-.17	.06	-.11	.00	NO_x
OX 4-7	.17	-.26	.03	.05	-.19	-.00	-.23	.08	HC
Palm Spr	-.02	-.18	-.25	-.11	-.16	.06	-.11	.01	NO_x
OX 5-8	.18	-.24	.05	.03	-.18	.01	-.19	.13	HC

Table 6.5 Oxidant-Precursor Correlations with Morning Inversion Base Height Stratification

	POM	DOLA	S BERN	LENX	WHT	AZUSA	ANH	PAS	
				IB < 1650'	N = 110-B	N = 67-PS			
Banning	-.02	-.32	-.15	-.32	-.40	.11	-.24	-.06	NO_x
OX 5-8	.14	-.33	.24	-.27	-.37	.06	-.38	.01	HC
Palm Spr	.21	-.15	-.23	-.24	-.29	.27	-.21	.06	NO_x
OX 4-7	.26	-.26	.05	-.22	-.22	.24	-.31	.11	HC
Palm Spr	.15	-.16	-.26	-.27	-.26	.25	-.20	.02	NO_x
OX 5-8	.24	-.20	.06	-.22	-.18	.25	-.23	.11	HC
				IB > 1650'	N = 107-B	N = 57-PS			
Banning	-.09	-.34	.07	-.09	-.13	.30	-.11	.11	NO_x
OX 5-8	.13	-.17	.12	.04	-.16	.03	-.31	.11	HC
Palm Spr	-.10	-.15	-.08	-.24	-.22	.30	-.29	-.06	NO_x
OX 4-7	.12	-.35	.07	-.06	-.32	.02	-.45	-.07	HC
Palm Spr	-.11	-.18	-.07	-.24	-.23	.31	-.27	-.06	NO_x
OX 5-8	.13	-.36	.07	-.07	-.31	.01	-.44	-.05	HC

Table 6.6 Summary of the Effects of Data Base Restrictions on Oxidant-Hydrocarbon Correlations

	POM	DOLA	S BERN	LENX	WHT	AZUSA	ANH	PAS	STRATIFICATION
Banning	.31	-.19	.25		-.21	.19	-.30		NONE
Palm Spr	.18	-.20			-.20		-.30		
Banning	.24		.27		-.17	.18	-.22	.18	WS > 3
Palm Spr	.20	-.21			-.20		-.29		
Banning	.25		.26			.15	-.22	.17	WS > 4
Palm Spr	.19	-.21					-.30		
Banning	.26		.28				-.22	.18	WS > 5
Palm Spr	.20	-.19					-.27		
Banning		-.24			-.26		-.39		MH < 2950
Palm Spr		-.24					-.29		
Banning	.25		.20				-.21	.26	MH > 2950
Palm Spr									
Banning		-.33	.24	-.27	-.37		-.38		BI < 1650'
Palm Spr						.25			
Banning							-.31		BI > 1650'
Palm Spr		-.36			-.31		-.44		
Banning	.26		.23				-.19	.18	WD SOUTHWESTERLY
Palm Spr	.24	-.19					-.26		
	Δ		Δ			Δ		Δ	

Blank indicates not significant at 95% certainty

WS = wind speed

WD = wind direction

MH = (maximum) mixing height

BI = (morning) base of inversion height

are dominated by significant negative values as strong as -.44. Overall, we find that the oxidant-hydrocarbon correlations, which tend to be significant and positive for small source-receptor separations, become increasingly negative as this separation increases, so that at large separations they are consistently significant and negative. (See Figure 6.2.) This pattern which shows up in all five scenarios, is discussed further in Section 5.3.

The last regression of this scenario involved restricting the oxidant values at Banning and Palm Springs to 8 pphm or higher, on the grounds that on days with lower oxidant levels, there is probably less transport of coastal SCAB air into Banning and Palm Springs. Conversely, high oxidant is produced in this area usually when pollutant-laden air from the SCAB enters. The results of this regression, outlined in Table 6.7, are disappointing, in that significant positive or negative correlations are scarce. A sort with a higher oxidant threshold might yield stronger correlations, but the data base is not large enough to permit the use of a higher threshold.

The mixture of weak, positive, and negative oxidant-precursor correlation coefficients of scenarios 4 and 5 indicate that these may be somewhat more difficult to model than the shorter-range scenarios. We therefore recommend that modeling of long-range transport of precursors be attempted only after development of a successful model of short-range transport. The low and the negative correlations do not necessarily doom long-range modeling efforts to failure, but they will make the modeling effort much more challenging.

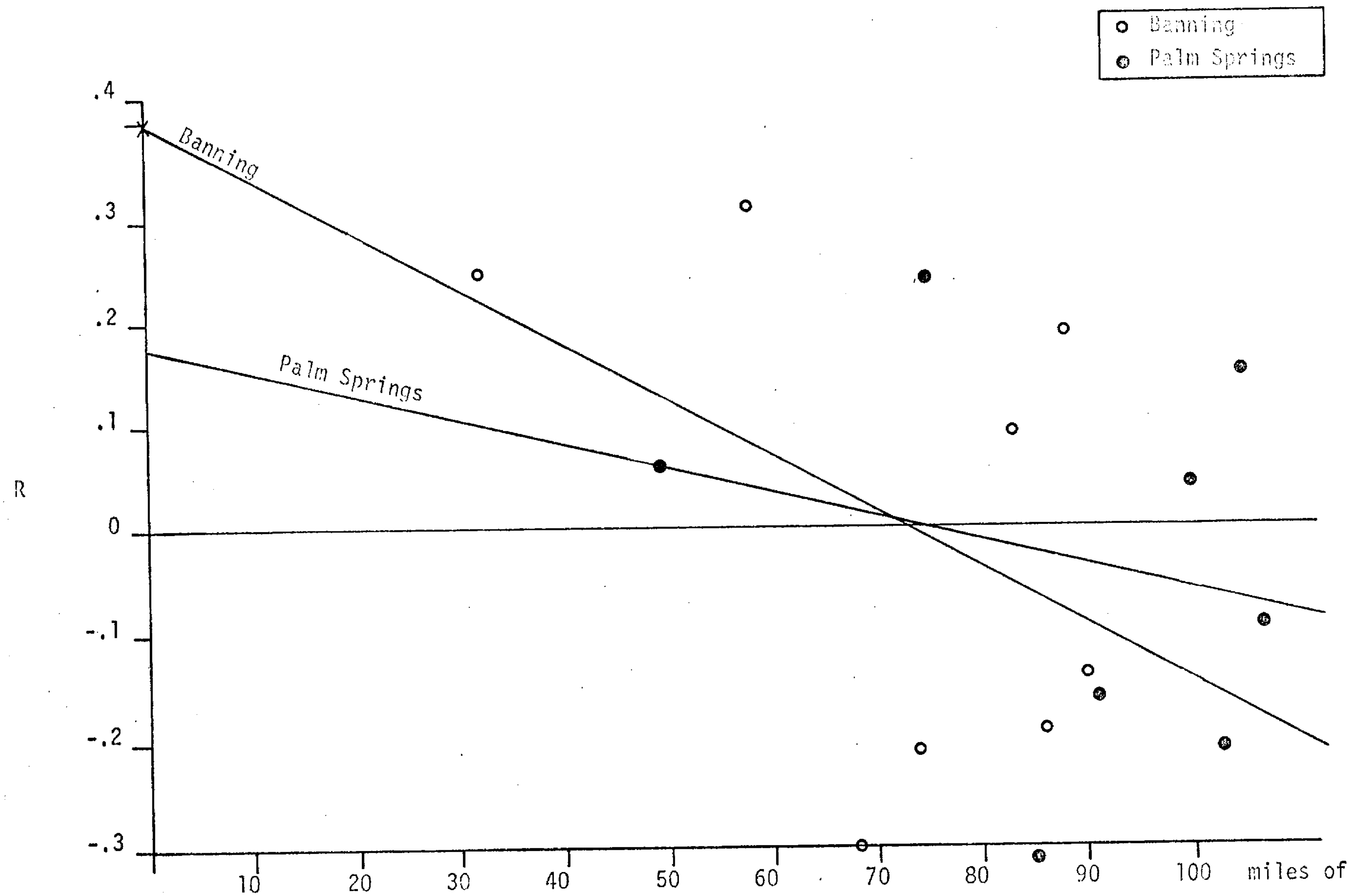

Figure 6.2. Oxidant-Hydrocarbon Correlations by Source-Receptor Separation

Table 6.7 Oxidant-Precursor Correlations with OX $\geq$ 8 PPHM

N = 112 $2/\sqrt{N} > .18$

	POM	DOLA	S BERN	LENX	WHT	AZUSA	ANH	PAS	
Banning	.19	.03	-.07	-.03	-.01	.17	.12	.24	NO_x
	.22	-.06	.21	.19	.01	.02	-.11	.15	HC

N = 50 $2/\sqrt{N} > .28$

	POM	DOLA	S BERN	LENX	WHT	AZUSA	ANH	PAS	
Palm Spr	.21	.03	.03	-.05	-.15	.05	-.01	.16	NO_x
OX 31	.34	-.24	.12	.17	-.15	.03	-.15	.10	HC
Palm Spr	.12	.03	-.04	-.03	-.10	-.01	.04	.07	NO_x
OX 32	.35	-.21	.06	.23	-.08	-.01	-.08	.07	HC

7.0 CONCLUSIONS AND RECOMMENDATIONS

The following are the most important findings, conclusions, and recommendations of this phase of the study:

1) The oxidant-precursor correlation coefficients are highly sensitive to the geographical separation of the source and receptor sites. The highest positive correlations, approximately +.6, are obtained with low-to-moderate range transport, such as DOLA to Pasadena. No transport (Scenario I) and moderate-range transport (Scenario II) have somewhat weaker positive correlations, in the range of .3 to .5. In Scenarios IV and V, long source-to-receptor distances are accompanied by significant negative correlations, approaching -.5. These negative correlations are particularly prevalent where Anaheim is the source site and Banning or Palm Springs is the receptor. Because of their prevalence, these negative correlations appear to be significant features of the data, rather than statistical "flukes." At <u>extremely</u> long transport distances, such as Lennox to Palm Springs, the correlations become insignificantly negative. This dependence of oxidant-precursor correlations on source-receptor separation appears consistently in all five scenarios and is discussed further in Section 5.3.

2) Positive oxidant-hydrocarbon correlation coefficients can be increased through judicious sorting of the data base by meteorology. For example, the data base can be restricted to days having winds of such speeds and directions as to boost the correlations. Similarly, higher correlation coefficients can be obtained when certain

linear combinations of oxidant at several receptor sites or of hydrocarbons or NO_x at several source sites are used. The model will be developed around a processed data base which reflects correlation-maximizing meteorological sorts and linear combinations of air quality data.

3) Where sources and receptors are widely spaced, negative and insignificant correlations are frequently obtained. In these cases, it is not clear that the data base should be stratified to increase or to decrease these correlations, since one does not necessarily anticipate strong oxidant-precursor correlations in these situations anyway. The best approach in these cases (e.g., in Scenarios IV and V) will be to stratify the data base on physical grounds, e.g., by limiting the data base to days with the wind at the right speed and direction to carry air from the sources to the receptors.

4) Sorting of the data base by wind direction at the 850mb level appeared to have an adverse effect on OX-precursor correlations. However, upper air transport should be irrelevant to the short-range transport scenarios and, even if physically significant in long-range transport, will not necessarily increase the long-range correlation coefficients, for reasons discussed above and in Section 5.3.

5) Sorting of the data base by mixing height was only slightly more successful than sorting by 850mb winds. Again, this is not too surprising, since mixing height will be most important to the long-range transport cases, in which the impact of a physically correct sort on correlation coefficients is not obvious.

6) Any modeling effort should treat the short-range transport scenarios first, attempting longer-range transport only if the short-range models are successful.

APPENDIX - ANALYSIS OF SO_2 AND NO_2 INTERFERENCE IN OX READINGS

This appendix describes our analysis of the effect of correcting oxidant measurements for NO_2 and SO_2 interference. We used data for 1973 from each station in the SCAB that measured OX, NO_2, and SO_2. The maximum one-hour oxidant concentration each day was corrected according to the formula:

$$[O_3] = [OX] - .2\ [NO_2] + [SO_2]$$

The NO_2 and SO_2 concentrations corresponded to the same hour as the daily maximum oxidant.

Table A shows the results of the analysis in terms of the correlation coefficient, regression equation, and average ratio between O_3 and OX. For the purposes of our empirical modeling study, the most significant result is the high correlation between O_3 and OX, ranging from .975 to .997 and averaging .989 among the various stations. The high correlation coefficients indicate that the day-to-day fluctuations in O_3 are very well represented by the day-to-day fluctuations in OX. Since <u>variations</u> in concentrations are the key to the empirical modeling study, we conclude that OX can be used as a replacement for O_3 in the statistical study. Using OX instead of O_3 will increase the size of our data base considerably because we will be able to include stations that lack NO_2 and SO_2 data and because we will not have to omit days with missing NO_2 and SO_2 data.

As indicated by the last column of Table A, the corrected O_3 values tend to be slightly greater than the OX readings (8% higher averaged over all stations). This indicates that the SO_2 interference is greater than the NO_2 interference. If we want to adjust our results for SO_2 and NO_2 interference, it would be appropriate to do the entire study using OX data alone and then correct the <u>final</u> results using the regression equation specific to each station.

Table A. Relationship of Daily Maximum OX Readings to O_3 Values Corrected for NO_2 and SO_2 Interference (1973 Data)

	CORRELATION COEFFICIENT	REGRESSION EQUATION $O_3 = A + B \cdot OX$ A(pphm)	B	RATIO O_3/OX
Azusa	.994	.9	1.05	1.12
Burbank	.990	.4	1.01	1.04
Lennox	.987	-.6	1.24	1.18
Long Beach	.981	-.8	1.24	1.08
Los Angeles	.975	.2	1.00	1.09
Newhall	.996	.9	.98	.97
Pasadena	.992	.3	1.01	1.04
Pomona	.997	.3	.98	1.05
Reseda	.995	.1	1.04	1.03
West Los Angeles	.980	.5	.98	1.05
Whittier	.977	-.2	1.11	1.20
Anaheim	.992	-1.2	1.28	1.15
La Habra	.995	-1.2	1.20	1.06
AVERAGE	.989			1.08